The Effects of the WISE/\textit{GALEX} Photometry for the SED-Fitting with M31 Star Clusters and Candidates

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ABSTRACT

Spectral energy distribution (SED) fitting of stellar population synthesis models is an important and popular way to constrain the physical parameters — e.g., the ages, metallicities, masses for stellar population analysis. The previous works suggest that both blue-bands and red-bands photometry works for the SED-fitting. Either blue-domained or red-domained SED-fitting usually lead to the unreliable or biased results. Meanwhile, it seems that extending the wavelength coverage could be helpful. Since the Galaxy Evolution Explorer (\textit{GALEX}) and Wide-field Infrared Survey Explorer (WISE) provide the FUV/NUV and mid-infrared \textit{W}1/\textit{W}2 band data, we extend the SED-fitting to a wider wavelength coverage. In our work, we analyzed the effect of adding the FUV/NUV and \textit{W}1/\textit{W}2 band to the optical and near-infrared \textit{UBVRIJHK} bands for the fitting with the Bruzual \& Charlot 2003 (BC03) models and \textit{galev} models. It is found that the FUV/NUV bands data affect the fitting results of both ages and metallicities much more significantly than that of the WISE \textit{W}1/\textit{W}2 band with the BC03 models. While for the \textit{galev} models, the effect of the WISE \textit{W}1/\textit{W}2 band for the metallicity fitting seems comparable to that of \textit{GALEX} FUV/NUV bands, but for age the effect of the \textit{W}1/\textit{W}2 band seems less crucial than that of the FUV/NUV bands. Thus we conclude that the \textit{GALEX} FUV/NUV bands are more crucial for the SED-fitting of ages and metallicities, than the other bands, and the high-quality UV data (with high photometry precision) are required.

Subject headings: galaxies: individual (M31) — galaxies: star clusters — globular clusters: general — star clusters: general

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1. Introduction

SED-fitting of the simple stellar population (SSP) models is an important method to estimate the physical parameters, e.g., the ages, metallicities and masses of star clusters by the $\chi^2_{\text{min}}$ techniques. It is based on the precise multi-band photometry and it has been applied in great number of recent works for the star clusters in the extra-galaxies. de Grijs et al. (2003) fit the SEDs from broad-band Ultra-violet (UV), optical to NIR observations of *Hubble Space Telescope* (*HST*) to derive age, metallicity and extinction of star cluster system of NGC 3310. Bastian et al. (2005) constrain the age, mass, extinction, and effective radius of 1152 star clusters in M51 by fitting the SEDs from the *HST* imaging from ultraviolet to near infrared, with Galaxy Evolutionary Synthesis Models (*galev*; Lilly & Fritze-v. Alvensleben 2006; Kotulla et al. 2009), which considers the gaseous emission lines as well as continuum emission and thus it is important for the young star clusters. Based on the Beijing-Arizona-Taiwan-Connecticut (BATC) multi-color photometry system, Fan et al. (2006); Ma et al. (2007, 2009, 2011, 2012); Wang et al. (2010, 2012) have done series of work on the SED-fitting of M31 star clusters with the SSP models such as Bruzual & Charlot (2003) models and *galev* models. In order to improve the fitting results and partly break the age-metallicity degeneracy, other photometry bands, such as the *UBVRI* broadband, Two Micron All Sky Survey (2MASS) *JHK* band, Galaxy Evolution Explorer (*GALEX*) near-ultraviolet (NUV) and far-ultraviolet (FUV), even the Sloan Digital Sky Survey (SDSS) *ugriz* bands are applied for the fitting, especially for the UV passband, (see, e.g., Kaviraj et al. 2007; Bianchi 2009). Fan et al. (2010); Fan & de Grijs (2012, 2014) also fit the SEDs of M31 and M33 star clusters in the *UBVRIJHK* bands and *ugriz* band with *Bruzual & Charlot* (2003) models/*galev*/BS-SSP models and PARSEC ISOCHRONES. Similarly, Kang et al. (2012) performed the photometry with *GALEX* NUV and FUV imaging data of star clusters and fitted the SED in up to 16 passbands ranging from FUV to NIR with data gathered from the literature values and the Revised Bologna Catalog (RBC v4) and they obtained ages and masses of 176 young ($\leq 1$ Gyr) clusters and 446 old ($> 1$ Gyr) clusters.

Since WISE provides near- and mid-infrared W1/W2 (3.4$\mu$/4.6$\mu$) band data respectively, we could extend to a wider wavelength coverage for the SED-fitting and check the effect of the WISE bands. As a matter of fact, in the similar bands, *Spitzer*- Infrared Array Camera (IRAC) colors has been applied for the stellar population analysis. For instance, Peletier et al. (2012) investigated the ([3.6]-[4.5]) color for the stellar populations in the early-type galaxies and found that the color is likely to be a good metallicity indicator: the color becomes bluer with increasing metallicity, which is attributed to the increasing importance of a CO absorption feature in the [4.5] bandpass. Barmby & Jalilian (2012) also analyzed the *Spitzer* IRAC colors with several stellar population synthesis models for the massive, old GCs in M31 and it is found that although the colors become slightly bluer with
age, the effect is quite small, just a few tenths of a magnitude. Further, the \([3.6]-[4.5]\) color
dose not show apparent relation with metallicity either for the models or for the cluster data. Meidt et al. (2012) found that the independent component analysis (ICA) technique with the
\([3.6]-[4.5]\) color can isolate the old stellar light from contaminant emission in a sample of six
disk galaxies. After removing the emission from evolved red objects with low mass-to-light
ratios, it is found that the underlying old distribution of light with \([3.6]-[4.5]\) colors is consistent
with the colors of K and M giants. Meidt et al. (2014) also found that the \([3.6]-[4.5]\) color is bluer at higher metallicity due to the CO absorption in the \([4.5]\) band for the giant
stars, but it is not very sensitive to age. Norris et al. (2014) also found that a linear relation
between the \(W1-W2\) color and metallicity for the nearby GCs and the early-type galaxies
although the scatter is large and only the models considering the effect of the increasing
CO absorption in the W2 band can successfully reproduce the observed trend. The \(W1-W2\) color is insensitive to age for age > 2 Gyr. It is also found that the mass-to-light ratio \(M/L\)
for old stellar population at 3.6 \(\mu m\) varies modestly with the age and metallicity (see, e.g.,
Querejeta et al. 2015), which is also confirmed by Röck et al. (2015), who found that both
\([3.6]-[4.5]\) color and \(W1-W2\) become only 0.01-0.02 mag redder with ages for ages above 2
Gyr and it becomes up to 0.04 mag bluer with increasing metallicity. Norris et al. (2016)
found that the \(W1\) band is an exceptional tracer of stellar mass for the quiescent/early-type
galaxies and it is highly recommended.

In fact, the effects and comparisons of different combinations of passbands for the SED
fitting have been studies in many previous works. Anders et al. (2004) investigate effects
cauised by the number of passbands, different passband combinations, observational errors
and non-continuous models, by fitting the SEDs of artificial star clusters with evolutionary
synthesis models with different set and number of passbands from \(UBVRIJH\). They found
that the \(U\) and \(B\) band are most important, and \(V\) and near-infrared are also helpful for
the fitting the age, metallicity, extinction and mass. As we mentioned above, de Grijs et al.
(2003) also investigated the effects by fitting the SEDs of NGC 3310 star clusters with differ-
ent passband combinations from UV to NIR observations of \(HST\) and they found that the
blue-selected passband combinations lead to a slightly bias towards lower ages but the red-
dominated passband combinations, especially dominated by NIR filters, should be avoided.
de Grijs et al. (2005) analyzed the systematic uncertainty of the SED-fitting with \(HST\)
imaging observations in UV+optical+NIR band and conclude that as extensive a wave-
length coverage as possible is required to obtain robust age and mass estimates for the
SED-fittings of various models with reasonable uncertainties. Kannappan & Gawiser (2007)
also fit different passband combination of the optical and NIR photometry with BC03 and
Maraston models and compared the stellar+gas mass with the dynamical mass in different
class of galaxies.
In this paper, we focus on the analysis and comparison of the parameters of age and metallicity, which could be derived directly from the SED-fit, while the mass is estimated with mass-to-light ratio $M/L$ and it depends on the estimated age and metallicity, which introduce the uncertainties again. Besides, the number of works for constraining masses of M31 star clusters is relatively less than that of ages and metallicities (even no masses included in the RBC catalog), which makes it more difficult to compare with, although WISE W1 is an exceptional tracer of mass after all. We compare the results of SED-fit with different combinations of the photometry bands, from GALEX FUV, NUV, to the JHK and WISE bands of the M31 star clusters. This paper is organized as follows. In Section 2 we describe the stellar population synthesis models applied in our work and the convolution of the AB magnitudes. In Section 3 we introduce our sample of M31 GCs and the fitting methods. In Section 4 we give the fitting results and comparisons of the ages and metallicities based on $\chi^2_{\text{min}}$ fitting, using various models and methods. Finally, we summarize our work and give the conclusions in Section 5.

2. The Models and $\chi^2_{\text{min}}$-fitting Method

In our work, two stellar population synthesis models are used.

1. The Bruzual & Charlot (2003, hereafter BC03) stellar population synthesis models provide SEDs of various physical parameters, such as ages, metallicities and masses. The stellar evolutionary tracks of Padova 1994 and 2000 Padova are given, and the Initial Mass Functions (IMFs) of Salpeter (1955) and Chabrier (2003) IMFs are provided. The wavelength ranges are from 91 Å to 160 µm. For the Padova 1994 tracks, models of metallicities for $Z = 0.0001, 0.0004, 0.004, 0.008, 0.02,$ and 0.05 are provided, as for the Padova 2000 tracks, models of metallicities ($Z = 0.0004, 0.001, 0.004, 0.008, 0.019,$ and 0.03) are given. Since the metallicity steps are too large for the fitting, we interpolate the models to attain smaller intervals of the parameter space, i.e. 51 metallicities with equal steps in logarithmic space) to obtain the subtle results. Meanwhile, 221 ages 0-20 Gyr in unequally spaced time steps are provided. Different combinations of Padova 1994/2000 stellar evolutionary tracks and IMFs are computed for the models. However, it is known that for a different IMF dose not affect the results including the uncertainties more significantly than the stellar evolutionary track dose. We should note that the best-fitting metallicity range for the Padova 2000 tracks is not as wide as that obtained from the Padova 1994 tracks due to the metallicity limitations of the models.

2. The galev models, which can be applied to constrain the chemical evolution of the gas and the spectral evolution of the stellar population in star clusters or galaxies simulta-
neously. The stellar evolutionary tracks/isochrones Padova and Geneva are provided, and in our work we adopt the Padova evolutionary track. The models not only give the photometry but also provide the Lick absorption-line indices for different stellar populations with different star-formation rates or even the SSPs for the single burst. For the ages, 5001 values 4 Myr - 20 Gyr provide by the models, and metallicities of $Z = 0.0001, 0.0004, 0.001, 0.004, 0.008, 0.02,$ and 0.05 are given, for which the grid step is too large. Thus we also interpolate the metallicities to a grid of 51 values which lead to more accurate results. The model spectra coverages the wavelength from XUV at $\sim 90$ Å to the FIR 160 $\mu$m, with a spectral resolution of 20 Å in the UV-optical and 50-100 Å in the NIR wavelength range. Then we convolve the model spectra with the filter transmissions and obtain the model magnitudes. Nevertheless as Fan & de Grijs (2012) pointed out, the galev models usually predict younger ages than other models, like BC03 and works better for young stellar populations.

In fact, Norris et al. (2014) found that many models, including the BC03 models and the galev models, fail to fit the observed $W_1$-$W_2$ colors of stellar populations dramatically around solar metallicity. The observed scatter is too large to make the $W_1$-$W_2$ color to be one metallicity indicator. These two models can give the correct zeropoint in the $W_1$ band, however they substantially underpredict the absolute zeropoint in the $W_2$ band. Röck et al. (2015) also suggest that the galev models predict redder color by about 0.10-0.13 of absolute values of the Spitzer ([3.6]-[4.5]) than that of their SSP models due to the theoretical stellar atmospheres and not considering the CO absorption in the 4.5 $\mu$m. Fortunately it is also well known that in continuing the trend for IR photometry, the WISE $W_1$ and $W_2$ bands have significantly reduced sensitivity to age and metallicity (see the discussion in Sect. III). Therefore it seems that the determination of age and metallicity is unaffected by the use of WISE photometry for the BC03 and galev models.

For both of the galev and BC03 SSP models, the theoretical spectra can be convolved to magnitudes in the AB system using the filter-response functions in FUV/NUV/UBVRIJHK bands and $W_1/W_2$ bands (Jarrett et al., 2011). The AB magnitudes of synthesis models are given by,

$$m_{AB}(t) = -2.5 \log \frac{\int_{\lambda_1}^{\lambda_2} d\lambda \; \lambda \; F_{\lambda}(\lambda, t) \; R(\lambda)}{\int_{\lambda_1}^{\lambda_2} d\lambda \; R(\lambda)} - 48.60,$$

where $R(\lambda)$ is filter-response function and $F_{\lambda}(\lambda, t)$ is the flux, which is a function of wavelength ($\lambda$) and evolutionary time ($t$). $\lambda_1$ and $\lambda_2$ are the lower and upper wavelength cutoffs of the respective filter.
3. The Cluster Sample Selection and the $\chi^2_{\text{min}}$-Fitting

In our work, we collected the photometry of M31 star clusters and candidates from ultraviolet bands to the middle infrared bands for the SED-fitting. For the photometry of FUV and NUV bands, i.e., Galaxy Evolution Explorer (GALEX) data, the $UBVRI$ broad band data and Two Micron All Sky Survey (2MASS) $JHK$ band data are from Revised Bologna Catalogue of M31 GCs and candidates (RBC v5, Galleti et al. 2004, 2006, 2009). Since the catalog also includes the non-cluster objects, such as stars or background galaxies, which may contaminate our fitting results, we then exclude these objects from the catalog and only include the star clusters and candidates in our sample, namely $f=1, 2$ or $8$ in RBC. In the catalog, the photometry only from the ultraviolet bands to the near-infrared bands (i.e., FUV and NUV bands of GALEX data, the $UBVRI$ band and 2MASS $JHK$ bands) are included. The RBC catalog dose not include the middle infrared photometry. Fortunately, All WISE Source Catalog of Infrared Processing and Analysis Center (IPAC) Infrared Science Archive (IRSA) provides the WISE (Wright et al. 2010) profile-fit photometry and curve-of-growth corrected “standard-aperture” photometry in $W1$, $W2$, $W3$, $W4$ bands, of which the central wavelengths are 3.4, 4.6, 12 and 22 µm. Since the profile-fit photometry provides the most accurate measurements for unresolved objects, we adopted it for our SED-fitting. The standard deviation of WISE magnitudes (limiting magnitudes) of 11 frames for the S/N of 5 are 17.11, 15.66, 11.40, and 7.97 mag in $W1$, $W2$, $W3$, $W4$ bands (Wright et al. 2010). It suggests that the sensitivity of $W3$, $W4$ bands are not high enough for the fitting of our M31 star cluster sample. Therefore, Table 1 only lists the WISE photometry associated with the uncertainties in $W1$, $W2$ bands, which are actually applied in our work. For the convenience of the fitting and comparisons, we only select the star clusters and candidates in RBC with the available photometry in all bands, namely from GALEX FUV, NUV, broadband $UBVRI$, 2MASS $JHK$ as well as the WISE $W1$, $W2$ bands. Finally we have only 123 star clusters and candidates in our sample. The photometry of WISE $W1$ and $W2$ bands are listed in Table 1 which are in the the Vega system.

The GALEX FUV, NUV data of the RBC are actually from the literature works of Rev et al. (2007) and Kang et al. (2012). For the former work, the authors applied the DAOPHOT II package (Stetson 1987) to perform the photometry in both FUV and NUV bands within a radius of 3 pixel ($4''.5$) for each point source. In FUV and NUV bands, 5-16 and 19-44 isolated stars per frame were applied for the aperture corrections. Kang et al. (2012) adopted the same photometry method and parameters as done by Rev et al. (2007).

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1http://www.bo.astro.it/M31/
2http://irsa.ipac.caltech.edu/Missions/wise.html
While for the WISE $W_1$, $W_2$, the azimuthally averaged PSF with FWHMs of 6′′.1 and 6′′.4 (Wright et al. 2010). Thus, although the background of the galaxy is complicated and pixel scale is relatively large, the background estimated is just in a very small region, slightly larger than the photometry aperture. Therefore, it is relatively uniform for the background flux subtraction and it dose not affect much of the photometry accuracy, which also can be seen from the photometry errors.

For the convenience of model SED-fitting, we convert all the photometry of Vega system to AB system in our sample for the bands from $UBVRIJHK$ and $W_1$, $W_2$ bands using the Kurucz (1992) SEDs. As we know, reddening values could affect SED fitting significantly. Although Schlafly & Finkbeiner (2011) recalibrate the infrared-based dust map of Schlegel, Finkbeiner & Davis (1998) with SDSS photometry to higher accuracy even outside of the SDSS footprint, they only consider the Galactic extinction. For reddening correction of M31 star clusters, and the reddening values of M31 galaxy should be considered as well. In our work, reddening values for our sample star clusters were adopted from Caldwell et al. (2011) and Fan et al. (2008), in higher priority of former work as their redenings of star clusters were derived from spectroscopy. For the unavailable ones not found in the literature works above, we adopted $E(B−V) = 0.24$ mag instead, which is the average reddening value of Caldwell et al. (2011), as the representative reddening value of M31 star clusters. The extinction $A_\lambda$ can be computed using the equations of Cardelli et al. (1989), and we adopted a typical foreground Milky Way extinction law, $R_V = 3.1$. We fitted the SEDs using

$$\chi^2_{\text{min}} = \min \left[ \sum_{i=1}^{8} \left( \frac{M_{\lambda_i}^\text{obs} - M_{\lambda_i}^\text{mod}(t, [Z/H])}{\sigma_{M,i}} \right)^2 \right], \tag{2}$$

where $M_{\lambda_i}^\text{mod}(t, [Z/H])$ is the $i^{\text{th}}$ magnitude provided in the stellar population model for age $t$, metallicity $[Z/H]$; $M_{\lambda_i}^\text{obs}$ represents the observed dereddened magnitude in the $i^{\text{th}}$ band.

Eq. 3 represents the errors associated with our SED-fittings,

$$\sigma_{M,i}^2 = \sigma_{\text{obs},M,i}^2 + \sigma_{\text{mod},M,i}^2, \tag{3}$$

where $\sigma_{M,i}$ is the magnitude uncertainty in the $i^{\text{th}}$ filter. For the photometric errors of RBC, Galleti et al. (2004) suggested for the typical error of CCD photometry are 0.08 mag in $U$, 0.05 mag in $BVRI$, 0.1 mag in $J$, and 0.2 mag in $HK$; for the photographic magnitudes the photometric error is 0.05-0.2 mag. Actually in the updated version of RBC v5, a series of high precision photometry have been included. In our sample, most of the photometry of RBC are from Barmby et al. (2000); Barmby & Huchra (2001) and Fan et al. (2010) and we adopted the photometric errors from these literature works if available. For those photometric errors which can not be found in the literature works, we adopted a mean photometric errors
depending on the brightness of the sources. The model errors adopted were 0.05 mag, which is the typical photometric error for the Bruzual & Charlot (2003) and GALEV SSP models (e.g., Fan et al. 2006; Ma et al. 2007, 2009; Wang et al. 2010; Fan & de Grijs 2014).

4. The Fitting Results and Discussion

In order to check the fitting results of our work when adding the WISE data, we compare that with the results from various literature works. Figure 1 shows the comparisons of metallicity fitted with Padova 2000 evolutionary track and Chabrier (2003) IMF of Bruzual & Charlot (2003) models and that from four of recent works. Chen et al. (2016) have determined the metallicities, ages and masses of 306 star clusters in M31, which are selected from the Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) spectral survey (Zhao et al. 2012). The metallicities derived from full spectral fitting of PEGASE-HR model and Vazdekis et al. (2010) model, as well as that derived from Lick Fe indices and EZ_Ages code are given in Chen et al. (2016). However we adopted the metallicities of PEGASE-HR model for the comparison, which seems most reliable and most comprehensive, and it is shown on the top left panel. The dashed line represents the best linear fit and the slope is 0.45, indicating a positive correlation between our SED-fitting result of BC03 model agree with that of Chen et al. (2016), with the systematic offset of $[\text{Fe/H}]_{\text{Chen+2016}} - [\text{Fe/H}]_{\text{our work}} = 0.06 \pm 0.65$ dex. The Top Right Panel shows the comparison between our fitting result and that of Caldwell et al. (2011), who have taken the high-quality spectra of 323 old M31 star cluster with the 6.5-m MMT telescope and they have determined the [Fe/H] by using the MW GC bi-linear relation and the Lick Fe indices. It seems the correlation between the metallicities from Caldwell et al. (2011) and our result is weak, with the linear fit slope (dashed line) of only 0.14, and systematic offset is $[\text{Fe/H}]_{\text{Caldwell+2011}} - [\text{Fe/H}]_{\text{our work}} = 0.01 \pm 0.53$ dex. Besides, Kang et al. (2012) provide a compiled catalog by collecting the metallicity measurements of 399 star clusters in M31 from the spectroscopic observations of Caldwell et al. (2011), Galleti et al. (2009), Perrett et al. (2002) and Barmby et al. (2000). The mean value of metallicity from the literature values is adopted in the catalog. However, for star clusters with a metallicity value in only one literature work, the value is adopted. The comparison is shown on the bottom left panel, suggesting that the metallicities of Kang et al. (2012) is slightly lower than that of our results, with systematic offset of $[\text{Fe/H}]_{\text{Kang+2012}} - [\text{Fe/H}]_{\text{our work}} = -0.04 \pm 0.68$ dex. The slope of the linear fit is $-0.02$, suggesting that there is almost no correlation between results of the two works, which may be due to the systematic offsets between literature values gathered in their final catalogue. In addition, Fan et al. (2010) updated the $UBVRI$ photometry and in order to determine the ages and masses of 445 confirmed globular-like and
candidate clusters of M31, the spectroscopic metallicities are collected from Perrett et al. (2002), Barmby et al. (2000) and Huchra et al. (1991), which are shown on the bottom right panel. It suggests that the metallicities from the compiled catalogue of Fan et al. (2010) is systematically higher than the value of our work, with the systematic offset of $[\text{Fe/H}]_{\text{Fan+2010}} - [\text{Fe/H}]_{\text{our work}} = 0.35 \pm 0.75$ dex. The slope of the linear fit is 0.67, indicating that their result is consistent with that of our work basically, at least showing a positive trend for the correlation.

Further the galev models of Kroupa (2001) IMF is also applied for the same comparisons as Figure 1 shown in Figure 2. It seems that the agreement of our results and that from literature works are better overall, which can be seen from the dashed lines (the slopes of linear fits). The systematic offsets are $0.17 \pm 0.51$, $0.11 \pm 0.39$, $0.07 \pm 0.54$ and $0.46 \pm 0.60$ and the slopes are 0.89, 0.67, 0.49 and 1.08 respectively in the order of literature works as Figure 1. We find that the systematic offset of Kang et al. (2012) is the smallest while that of Fan et al. (2010) is the largest, but seems all can be ignored if considering the errors; for the slope, it is found that Kang et al. (2012) is the worst fit while Fan et al. (2010) is the best. In fact the it can be seen that our fit results basically agree with the metallicities of Chen et al. (2016) and Caldwell et al. (2011).

Figure 3 is the same as Figure 1 but for comparisons of the ages, derived from SED-fitting with Padova 2000 evolutionary track and Chabrier (2003) IMF of Bruzual & Charlot (2003) model and that from literature works: Chen et al. (2016) obtained the ages through full-spectral fitting the LAMOST data with PEGASE-HR models / Vazdeks models. Although the EZAges code and SED-fitting of ugriz bands also have been applied for the age estimates, the ages from PEGASE-HR models seems most reliable and are adopted for the comparison as discussed above, which is shown on the Top Left Panel. It is found for the most old star clusters, i.e., age log $t > \sim 9.5$ (yr), the agreement is roughly good, while for the clusters younger than that, our fits gives younger ages. The dashed line is the best linear fit and the slope is 0.01. It can be seen that the ages of Chen et al. (2016) seems in a consistent range between log $t \sim 9.5$ and $\sim 10.3$ (yr). As we discussed above, Caldwell et al. (2011) determined the ages of a sample of M31 GCs with the EZAges and the Lick indices from MMT spectra. However, for clusters which fall outside the index - index grids, the ages are set to 14 Gyr. The comparison is shown on the Top Right Panel, from which it is found that most ages from the fitting of Caldwell et al. (2011) are at the upper limit. The slope of the linear fit is $-0.04$ and it can be seen that as most of the ages are at the upper limit, which makes it seem that the ages from Caldwell et al. (2011) are almost constant, independent of our result. Kang et al. (2012) estimate the ages of 182 young clusters (younger than 1 Gyr) by multi-band SED fitting, which is shown on the Bottom Left Panel. It seems that the ages of Kang et al. (2012) are systematically younger ($\sim 0.3$ dex) than that of our
estimates. The slope of the best fit is 0.57, suggesting that the agreement is not good, but the trend is positive. The ages of 445 confirmed globular-like and candidate clusters from Fan et al. (2010) are determined by $\chi^2_{\text{min}}$-fitting of the $UBVRIJK$ photometry and the BC03 models, for which the comparison are shown on the Bottom Right Panel. The slope of the best linear fit is 0.59, and we found that the ages derived from Fan et al. (2010) are younger than our results for $\log t \sim 10$ (yr).

Similar to Figure 3, we also plot the age comparison of GALEV models of Kroupa (2001) IMF in Figure 4. The slopes of the best linear fits are 0.20, $-0.02$, 0.60 and 1.24 respectively in the order of literature works as Figures above. We find that for the Fan et al. (2010) the agreement is the best, while for Caldwell et al. (2011) and Chen et al. (2016) the agreement seems not good and ages from literature works seems independent of our fit ages, which is may be due to the same reason as Figure 3. While for the ages of Kang et al. (2012), our result is basically agree with the literature values.

Before compare the different sets of photometry passbands, we would like to know that the effects of different stellar evolutionary tracks and different IMFs. We compared the metallicity derived from different stellar evolutionary tracks and IMFs of the Bruzual & Charlot (2003) models in Figure 5. The photometry of all bands are used for the fittings on all the panels. The Top Left Panel shows the comparisons of Padova 1994 and Padova 2000 evolutionary tracks with same IMF of Salpeter (1955), and the comparison of fitting results due to the two different tracks with same IMF of Chabrier (2003) are shown on the Top Right Panel. It can be seen that for the metallicity $[\text{Fe/H}] > -1.3$ dex, the metallicities derived from two evolutionary tracks basically consistent with each other, although there are few outliers with $[\text{Fe/H}] > 0$ dex in the fitting of Padova 1994 track where the Padova 2000 fits seems systematically lower. However, since the lower limit of the metallicity of the two tracks are different, i.e. $[\text{Fe/H}] = -2.2490$ for Padova 1994 and $[\text{Fe/H}] = -1.6469$ for Padova 2000, the difference between the results derived from the two evolutionary tracks becomes significant, especially for metallicity close to the lower limit of Padova 2000 evolutionary tracks. It can be seen that the upper two panels are almost in the same case and the IMF almost dose not affect the fits. Similarly, the comparisons of different IMFs of Salpeter (1955) and Chabrier (2003) with Padova 1994 evolutionary tracks are shown on Bottom Left Panel; the same comparison but with Padova 2000 evolutionary tracks are shown on Bottom Right Panel. Apparently the metallicities derived from IMFs of Salpeter (1955) and Chabrier (2003) agree with each other very well for any case, which also suggests that the IMF dose not affect models significantly.

Figure 6 is the same as Figure 5 but for the ages, which are also derived from evolutionary tracks of Padova 1994/Padova 2000 on the top panels and IMFs of Chabrier (2003)/Salpeter
of the Bruzual & Charlot (2003) models on the bottom panels. The photometry of all bands are used for the fitting. From the top panels we can see that the results derived from the two different evolutionary tracks, Padova 1994 or the Padova 2000, basically consist with each other for both young and old ages, except for some outlier which seems older in Padova 1994 models but younger in Padova 2000 models. The dashed lines are the best linear fit, showing the difference of results fit by two evolutionary tracks. On the bottom panels, again we found that the results from IMFs of Chabrier (2003) and Salpeter (1955) agree with each other very well, although there are some outliers. It suggests that for the Bruzual & Charlot (2003) models, the IMFs of Chabrier (2003) and Salpeter (1955) do not significantly affect the fitting results, either for the Padova 1994 or the Padova 2000 evolutionary tracks. Since the Chabrier (2003) IMF and Padova 1994 evolutionary track are more up-to-date, we will apply them in the following work.

In order to figure out the effects of the FUV, NUV and W1, W2 in the SED-fitting, we compare the results with different sets of photometry passband combinations. Table 2 is the Ages and Metallicities Derived from the SED $\chi^2_{\text{min}}$-fitting with BC03 models (Bruzual & Charlot 2003) of Padova 2000 stellar evolutionary track and IMF of Chabrier (2003), which is more up-to-date. The three cases are considered in our work: 1. fitting with all bands (FUV, NUV, UBVRIJHK, W1, W2); 2. fitting without WISE data (FUV, NUV, UBVRIJHK); 3. fitting without GALEX data (UBVRIJHK, W1, W2). Figure 7 presents the comparisons of metallicities fitted with Bruzual & Charlot (2003) models and photometry in all bands and that without GALEX data on the Left Panel or the fitting without WISE data on the Right Panel. Obviously, it found that the fitting without WISE data agree significantly better with the fitting of all band than the case without GALEX data as the scatter is much smaller. It may indicate that effect of the GALEX data plays an much more significantly role than that of WISE data, or say, the SED-fitting is much more sensitive to the GALEX data than that of WISE data. Therefore the precision of the GALEX UV bands is important for the fitting results. Figure 8 is the same but shows the comparisons of ages from with photometry of all bands and that without GALEX data on the Left Panel and that without WISE data on Right Panel. Again, the “best” assumptions, Padova 2000 evolutionary track and Chabrier (2003) IMF are applied in the fitting. Similarly, we found that the ages from fitting without WISE data agree much better with fitting of all band than the case without GALEX data. However it is worth noting that some outliers around log $t \sim 9.2$ fitted without WISE data but log $t \sim 10.2$ fitted with all-band or log $t \sim 10.3$ fitted without WISE data but log $t \sim 9.2$ fitted with all-band, which seems lead to “unstable” results. We have check the fit carefully and found the photometry and fits are good. It may be due to that the models have very small distance between the two parameter node. Further we also can see that the number of the points is quite few compared
to the whole sample. Actually it is found that the agreement is good in general. Thus we conclude that the GALEX data is much more sensitive to the SED-fittings than the case without WISE data in the Bruzual & Charlot (2003) models. In addition, we found that for the clusters with age log $t > \sim 10$ (yr) for the all-band fitting, the results from fitting without GALEX data seems systematically younger, while for clusters $\sim 9 < \log t < \sim 9.5$ the results agree with each other well although there are some outliers likely to be older than that fit with all-band data.

Furthermore, we also would like to see the effect of the different IMF for the GALEV models. Figure 9 is the same as Figure 5 but for comparisons of metallicity fitted with GALEV models. The fitting results of Kroupa (2001)/Scalo/Salpeter (1955) IMFs are compared. We found that the fitting results of the three IMFs are basically the same, suggesting that the effect on different IMF for the GALEV models are quite slight on metallicity, which is even can be ignored. Figure 10 is the same as Figure 6 but showing ages derived models with different IMFs of Kroupa (2001)/Scalo/Salpeter (1955). The comparisons shows that the IMFs seems almost do not affect the fitting results either. However, we prefer the IMF of Kroupa (2001), which is more up-to-date and reasonable.

We also would like to check the effect of the GALEX FUV and NUV bands and that of the WISE W1 and W2 bands for SED-fitting with the galev models. Table 3 is the same as Table 2 but for the ages and Metallicities derived from the SED fitting with galev models and Kroupa IMF. All the three cases are considered: 1. fitting with all bands (FUV, NUV, $UBVRIJHK, W1, W2$); 2. fitting without WISE data (FUV, NUV, $UBVRIJHK$); 3. fitting without GALEX data ($UBVRIJHK, W1, W2$). Figure 11 is the same as Figure 7 but for the galev models of Kroupa (2001) IMF. We compared the fitting metallicities with photometry in all bands and that without GALEX data on the Left Panel, and the comparison of that without WISE data on the Right Panel. The dashed lines are the best linear fits. We found that the results basically consist with each other for both left and right panels, despite of scatters and a few outliers. For the left panel, it is found that the fitting without GALEX data will lead to higher metallicity around $[\text{Fe/H}] \sim -1$ in the all-band fit. While the right panel shows that the metallicity fitted without WISE data seems higher than that fitted with all-band photometry for $[\text{Fe/H}] < \sim -1$.

Figure 12 is the same as Figure 8 but for ages fitted with the GALEV models of Kroupa (2001) IMF. It shows the fitting results from GALEV models Kroupa (2001) IMF with all-band photometry and the fitting results without GALEX data on the Left Panel and the fitting results without WISE data on the Right Panel. The dashed lines are the best linear fit and it seems the ages derived without GALEX is systematically older than that from all-band fit by $\sim 0.2$ dex. However the ages fitted without WISE data agree well with that
of all-band fit on the right panel. Thus it is found that the fitting results are much more sensitive to the FUV and NUV bands of *GALEX* than that of the WISE *W1* and *W2* bands, since the agreement of fitting results is much better for the latter than that for the former. On the other hand, the uncertainties of ages increase significantly when the FUV and NUV band data are involved in the fitting, indicating that the high-quality FUV and NUV data is much more important for the age-fitting than the *W1* and *W2* bands. In other words, introducing the WISE *W1* and *W2* bands data to the SED-fitting is helpful but not as significant for the age fitting of the *galev* models as that of the FUV and NUV data.

### 5. Summary and Conclusion

In our work, we collected the photometry of M31 star clusters and candidates from ultraviolet bands to the middle infrared bands for the SED-fitting. For the photometry, the FUV and NUV bands, *UBVRI* broadband, 2MASS *JHK* bands are from RBC v5 catalog. The WISE *W1/W2* band photometry are downloaded from the IPAC/IRAS website. The $\chi^2_{\text{min}}$ technique is applied for the SED-fitting.

The [Bruzual & Charlot (2003)](#) models with Padova 2000 track and [Chabrier (2003)](#) IMF are adopted in the fitting, which are more up-to-date. First we compare our fitting results with the recent works of [Chen et al. (2016)](#), [Caldwell et al. (2011)](#), [Kang et al. (2012)](#) and [Fan et al. (2010)](#), which give the fitting results of large samples of star clusters.

1. For the metallicity, our fitting result agree with that of [Chen et al. (2016)](#) in general, with the systematic offset of 0.06 ± 0.65 dex. While the correlation between the metallicities from [Caldwell et al. (2011)](#) and our result seems weak, but the systematic offset is only 0.01 ± 0.53 dex, which shows good consistency at the average level. The metallicities of [Kang et al. (2012)](#) is slightly lower than that of our results, with systematic offset of −0.04 ± 0.68 dex. The metallicities of [Kang et al. (2012)](#) is almost independent of our fits, which may be due to the systematic offsets of metallicities that the authors gathered from various literature works. While for comparison of [Fan et al. (2010)](#), it suggests that the metallicities are systematically higher than that of our work, with the systematic offset of 0.35 ± 0.75 dex and their result is consistent with that of our work in general. We also compared with *galev* models and it is found that the metallicities from literature works agree with our fitting results better than that of [Bruzual & Charlot (2003)](#) models overall, especially for [Caldwell et al. (2011)](#) and [Chen et al. (2016)](#).

2. For the comparison of ages from literature works, we found the results of both [Caldwell et al. (2011)](#) and [Chen et al. (2016)](#) are almost independent of our results derived
from either Bruzual & Charlot (2003) models or the galev models, which may be due to the reason that the ages of the two literature works are concentrated in a very narrow range or at an upper limit in the fitting. However for the results of Kang et al. (2012) and Fan et al. (2010), the best linear fit shows positive correlations and agreements with our results in general for both models.

We compared the effects of the different IMFs and evolutionary tracks for the SED-fitting:

1. For the Bruzual & Charlot (2003) models, it is found that fitted metallicities of the models with Padova 1994 and the Padova 2000 evolutionary tracks are basically consistent with each other for $[\text{Fe/H}] \sim -1.3$ dex with the IMF of either Salpeter (1955) or Chabrier (2003), despite of systematic offset for few outliers with $[\text{Fe/H}] > 0$. However for the metallicity close to the lower limits of the Padova 2000 tracks, the difference between the two fitting results becomes significant. It is also noted that for either Padova 1994 and the Padova 2000 evolutionary track, different IMF does not affect the result significantly. While for ages, the results derived from the evolutionary tracks of Padova 1994 and Padova 2000 agree with each other better than that for metallicity, except for a few outliers. Again different IMF seems not affect the fitted ages significantly for either Padova 1994 or Padova 2000 evolutionary tracks.

2. For the galev models, the different IMFs have been compared in the SED-fitting. We found that the effects of different IMFs for Kroupa (2001)/Scalo/Salpeter (1955) are quite insignificant for either metallicity-fitting or the age-fitting.

Further we investigated the fitting results of different passband combinations. Three main cases are considered in our analysis: 1. fitting with all bands (FUV, NUV, $UBVRIJHK$, $W_1$, $W_2$); 2. fitting without WISE data (i.e., FUV, NUV, $UBVRIJHK$); 3. fitting without GALEX data (i.e., $UBVRIJHK$, $W_1$, $W_2$). Two different SSP models, Bruzual & Charlot (2003) and galev are applied in the comparison and analysis:

1. For the Bruzual & Charlot (2003) models with Padova 2000 tracks, for either ages or metallicities, the fitting results without WISE data agree with that of all-band data better than the case fitting without GALEX data and fitting with all-band data. Thus we conclude that the GALEX data is more sensitive to the SED-fittings than the WISE data with the Bruzual & Charlot (2003) models.

2. For the GALEX models with IMF of Kroupa (2001), for metallicity, the fitting results either without GALEX data or without WISE data agree with all-band fitting results in general. However, for the fitting of ages, GALEX data seems affect the fitting results more significantly than the WISE data.
Therefore, it is found that *GALEX* FUV and NUV bands play more important roles for the fitting than that of WISE W1 and W2 bands and the observing accuracy of FUV and NUV bands are more crucial than that of the mid-infrared bands, such as W1 and W2.

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Table 1. The WISE Photometry in W1/W2 bands, which is downloaded from All Wise Source Catalog of IPAC Infrared Science Archive (IRSA), [http://irsa.ipac.caltech.edu/Missions/wise.html](http://irsa.ipac.caltech.edu/Missions/wise.html). We only list the W1/W2 bands, which are reliable for the fittings.

| Name  | W1 (mag) | W2 (mag) | Name  | W1 (mag) | W2 (mag) |
|-------|----------|----------|-------|----------|----------|
| B003  | 15.05 ± 0.04 | 15.03 ± 0.07 | B009 | 14.32 ± 0.03 | 14.77 ± 0.06 |
| B010  | 13.88 ± 0.03 | 13.63 ± 0.03 | B011 | 13.67 ± 0.03 | 14.09 ± 0.04 |
| B012  | 12.69 ± 0.02 | 12.73 ± 0.02 | B019 | 11.91 ± 0.02 | 11.95 ± 0.02 |
| B020  | 12.12 ± 0.02 | 12.18 ± 0.02 | B022 | 15.19 ± 0.04 | 15.50 ± 0.09 |
| B023  | 10.64 ± 0.02 | 10.67 ± 0.02 | B025 | 13.94 ± 0.06 | 13.76 ± 0.04 |
| B027  | 13.07 ± 0.04 | 13.11 ± 0.03 | B038 | 13.62 ± 0.04 | 13.77 ± 0.04 |
| B046  | 15.20 ± 0.04 | 15.35 ± 0.08 | B047 | 14.94 ± 0.03 | 14.97 ± 0.06 |
| B048  | 13.04 ± 0.04 | 13.34 ± 0.07 | B049 | 14.88 ± 0.10 | 14.16 ± 0.05 |
| B058  | 12.34 ± 0.03 | 12.38 ± 0.03 | B061 | 12.93 ± 0.03 | 12.94 ± 0.03 |
| B064  | 13.35 ± 0.07 | 13.81 ± 0.21 | B065 | 14.43 ± 0.03 | 14.79 ± 0.05 |
| B074  | 14.07 ± 0.03 | 14.11 ± 0.04 | B076 | 14.18 ± 0.16 | 14.35 ± 0.14 |
| B081  | 13.92 ± 0.04 | 14.17 ± 0.04 | B083 | 14.48 ± 0.03 | 14.57 ± 0.05 |
| B085  | 14.49 ± 0.03 | 14.65 ± 0.05 | B086 | 12.07 ± 0.05 | 12.44 ± 0.07 |
| B088  | 12.12 ± 0.03 | 12.14 ± 0.02 | B096 | 12.12 ± 0.04 | 12.88 ± 0.07 |
| B100  | 15.03 ± 0.10 | 15.31 ± 0.11 | B101 | 13.28 ± 0.08 | 13.82 ± 0.14 |
| B103  | 11.20 ± 0.04 | 11.98 ± 0.05 | B107 | 11.99 ± 0.04 | 12.71 ± 0.05 |
| B110  | 12.26 ± 0.03 | 12.31 ± 0.03 | B126 | 11.62 ± 0.04 | 13.35 ± 0.10 |
| B135  | 13.04 ± 0.03 | 13.08 ± 0.03 | B147 | 12.05 ± 0.04 | 12.52 ± 0.07 |
| B148  | 11.85 ± 0.06 | 12.79 ± 0.13 | B151 | 11.14 ± 0.03 | 11.35 ± 0.03 |
| B153  | 12.23 ± 0.05 | 13.01 ± 0.09 | B158 | 11.77 ± 0.02 | 11.86 ± 0.02 |
| B165  | 14.02 ± 0.09 | 14.14 ± 0.11 | B174 | 12.47 ± 0.03 | 12.52 ± 0.03 |
| B178  | 12.46 ± 0.05 | 12.57 ± 0.06 | B179 | 12.50 ± 0.05 | 12.79 ± 0.06 |
| B181  | 13.52 ± 0.07 | 13.31 ± 0.06 | B182 | 12.23 ± 0.03 | 12.33 ± 0.03 |
| B193  | 12.07 ± 0.03 | 12.12 ± 0.03 | B194 | 14.74 ± 0.23 | 14.87 ± 0.22 |
| B205  | 12.61 ± 0.04 | 12.62 ± 0.04 | B206 | 12.40 ± 0.04 | 12.41 ± 0.04 |
| B207  | 15.13 ± 0.06 | 15.30 ± 0.10 | B211 | 14.30 ± 0.07 | 14.57 ± 0.08 |
| B212  | 13.08 ± 0.03 | 13.13 ± 0.03 | B218 | 11.88 ± 0.03 | 11.92 ± 0.03 |
| B224  | 13.30 ± 0.04 | 13.36 ± 0.04 | B225 | 10.97 ± 0.02 | 11.00 ± 0.02 |
| B229  | 14.24 ± 0.08 | 14.21 ± 0.08 | B230 | 13.82 ± 0.03 | 13.83 ± 0.04 |
| B232  | 13.27 ± 0.03 | 13.28 ± 0.03 | B233 | 13.13 ± 0.03 | 13.18 ± 0.03 |
### Table 1—Continued

| Name  | W1 (mag) | W2 (mag) | Name  | W1 (mag) | W2 (mag) |
|-------|----------|----------|-------|----------|----------|
| B235  | 13.28 ± 0.05 | 13.26 ± 0.06 | B237  | 14.73 ± 0.04 | 14.81 ± 0.07 |
| B240  | 12.79 ± 0.02 | 12.83 ± 0.03 | B255  | 15.06 ± 0.07 | 15.38 ± 0.09 |
| B289  | 13.77 ± 0.02 | 13.70 ± 0.03 | B292  | 14.87 ± 0.03 | 14.92 ± 0.05 |
| B293  | 13.97 ± 0.03 | 13.88 ± 0.03 | B302  | 14.50 ± 0.04 | 14.54 ± 0.06 |
| B304  | 14.51 ± 0.03 | 14.52 ± 0.05 | B310  | 14.62 ± 0.03 | 14.65 ± 0.05 |
| B311  | 12.73 ± 0.03 | 12.77 ± 0.03 | B312  | 12.67 ± 0.03 | 12.71 ± 0.03 |
| B313  | 12.98 ± 0.03 | 12.97 ± 0.03 | B315  | 14.20 ± 0.04 | 14.49 ± 0.05 |
| B317  | 14.48 ± 0.03 | 14.53 ± 0.05 | B321  | 14.60 ± 0.04 | 14.35 ± 0.04 |
| B325  | 14.58 ± 0.05 | 14.68 ± 0.06 | B327  | 14.19 ± 0.05 | 14.53 ± 0.05 |
| B330  | 13.98 ± 0.04 | 15.30 ± 0.12 | B337  | 14.28 ± 0.03 | 14.23 ± 0.04 |
| B338  | 11.75 ± 0.04 | 11.81 ± 0.04 | B343  | 13.96 ± 0.03 | 13.98 ± 0.04 |
| B345  | 14.31 ± 0.05 | 14.26 ± 0.05 | B347  | 14.22 ± 0.03 | 14.21 ± 0.04 |
| B350  | 14.27 ± 0.03 | 14.32 ± 0.04 | B352  | 14.22 ± 0.03 | 14.25 ± 0.04 |
| B356  | 14.21 ± 0.03 | 14.27 ± 0.05 | B358  | 12.95 ± 0.02 | 12.97 ± 0.03 |
| B361  | 14.69 ± 0.03 | 14.92 ± 0.06 | B365  | 14.20 ± 0.03 | 14.29 ± 0.04 |
| B370  | 13.32 ± 0.03 | 13.37 ± 0.04 | B377  | 14.82 ± 0.03 | 14.92 ± 0.06 |
| B380  | 15.10 ± 0.05 | 15.48 ± 0.11 | B382  | 15.12 ± 0.04 | 15.54 ± 0.10 |
| B386  | 12.85 ± 0.02 | 12.85 ± 0.03 | B396  | 15.13 ± 0.03 | 15.13 ± 0.07 |
| B405  | 12.61 ± 0.02 | 12.65 ± 0.02 | B411  | 14.26 ± 0.03 | 13.94 ± 0.03 |
| B412  | 13.74 ± 0.03 | 13.59 ± 0.03 | B467  | 15.32 ± 0.04 | 15.40 ± 0.09 |
| B472  | 12.53 ± 0.05 | 12.50 ± 0.04 | B475  | 14.52 ± 0.06 | 15.10 ± 0.11 |
| B486  | 15.36 ± 0.04 | 15.23 ± 0.07 | G001  | 10.78 ± 0.02 | 10.83 ± 0.02 |
| G002  | 13.58 ± 0.03 | 13.56 ± 0.03 | G085  | 14.71 ± 0.05 | 15.28 ± 0.09 |
| G260  | 14.61 ± 0.03 | 14.69 ± 0.06 | G327  | 13.57 ± 0.02 | 13.63 ± 0.03 |
| G353  | 14.86 ± 0.03 | 14.81 ± 0.05 | VDB0  | 12.73 ± 0.03 | 12.67 ± 0.03 |
| B011D | 11.90 ± 0.02 | 11.80 ± 0.02 | B108D | 14.81 ± 0.06 | 14.95 ± 0.09 |
| B110D | 15.16 ± 0.21 | 15.16 ± 0.12 | B134D | 14.41 ± 0.03 | 13.96 ± 0.03 |
| B165D | 14.38 ± 0.03 | 14.23 ± 0.04 | B167D | 15.38 ± 0.04 | 15.26 ± 0.07 |
| B233D | 12.56 ± 0.02 | 12.28 ± 0.02 | B256D | 13.43 ± 0.04 | 13.69 ± 0.05 |
| B344D | 14.50 ± 0.03 | 14.45 ± 0.04 | BA11  | 15.23 ± 0.04 | 15.03 ± 0.06 |
Table 1—Continued

| Name  | W1     | W2     | Name  | W1     | W2     |
|-------|--------|--------|-------|--------|--------|
|       | (mag)  | (mag)  |       | (mag)  | (mag)  |
| BA22  | 14.67 ± 0.03 | 14.38 ± 0.04 | BH05  | 13.77 ± 0.05 | 13.93 ± 0.05 |
| SK107B| 12.74 ± 0.07 | 13.77 ± 0.14  |       |        |        |
Table 2. Ages and Metallicities Derived from the SED fitting with BC03 models of Padova 1994 stellar evolutionary track. The IMFs of Salpeter (1955) and Chabrier (2003) are adopted.

| No. | Name | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) |
|-----|------|--------------|-----------|--------------|-----------|--------------|-----------|
| 1   | B003 | -1.63±0.11   | 12.250±3.230 | -1.63±0.10  | 12.250±2.593 | -1.61±0.29  | 8.750±5.600 |
| 2   | B009 | -1.53±0.10   | 10.500±1.119 | -1.53±0.10  | 10.500±0.631 | -1.57±0.06  | 14.250±9.171 |
| 3   | B010 | -0.98±0.05   | 1.43±0.030  | -1.63±0.05  | 17.000±3.000 | -0.64±0.12  | 1.700±0.102 |
| 4   | B011 | -0.85±0.05   | 1.43±0.005  | -1.07±0.05  | 1.43±0.037  | -0.58±0.15  | 2.750±0.631 |
| 5   | B012 | -1.44±0.04   | 1.90±0.129  | -1.07±0.04  | 1.43±0.013  | -0.63±0.28  | 3.500±1.929 |
| 6   | B019 | -1.38±0.04   | 20.00±0.144 | -1.38±0.04  | 20.00±0.889 | -0.84±0.13  | 12.000±4.718 |
| 7   | B020 | -1.41±0.04   | 20.00±0.000 | -1.39±0.06  | 20.00±0.933 | -0.82±0.15  | 12.000±5.361 |
| 8   | B022 | -0.84±0.10   | 1.27±0.031  | -1.32±0.13  | 2.00±0.163  | -1.03±0.22  | 1.27±0.042  |
| 9   | B023 | -1.40±0.07   | 20.00±0.000 | -1.39±0.06  | 20.00±0.889 | -0.95±0.14  | 12.000±5.000 |
| 10  | B025 | -1.61±0.24   | 1.70±0.337  | -1.63±0.14  | 1.80±0.217  | -1.63±0.27  | 1.800±0.262  |
| 11  | B027 | -1.63±0.07   | 14.75±3.222 | -1.62±0.10  | 16.500±3.500 | -1.38±0.19  | 7.000±5.186  |
| 12  | B038 | -1.63±0.07   | 1.27±0.050  | -1.63±0.05  | 1.278±0.062 | -1.26±0.12  | 1.278±0.052  |
| 13  | B046 | -1.03±0.07   | 1.43±0.055  | -0.96±0.07  | 1.43±0.021  | -0.78±0.19  | 2.600±1.903  |
| 14  | B047 | -1.52±0.12   | 2.40±0.463  | -1.52±0.11  | 2.40±0.335  | -1.63±0.14  | 6.500±2.929  |
| 15  | B048 | -1.63±0.03   | 20.00±0.000 | -1.63±0.02  | 20.000±0.000 | -0.76±0.15  | 3.750±2.626  |
| 16  | B049 | -0.97±0.07   | 1.43±0.023  | -0.09±0.07  | 0.64±0.037  | 0.28±0.09   | 6.410±0.078  |
| 17  | B058 | -1.57±0.07   | 17.250±2.750 | -1.55±0.06  | 17.750±2.250 | -1.20±0.15  | 11.000±6.976  |
| 18  | B061 | -1.63±0.03   | 1.609±0.194  | -1.63±0.00  | 1.43±0.015  | -1.23±0.19  | 19.500±5.500  |
| 19  | B064 | -1.04±0.06   | 1.43±0.030  | -1.05±0.06  | 1.43±0.026  | -0.66±0.14  | 1.700±0.464  |
| 20  | B065 | -1.61±0.17   | 10.500±1.015 | -1.46±0.12  | 11.250±1.654 | -1.57±0.23  | 6.500±4.386  |
| 21  | B074 | -1.63±0.09   | 13.750±2.163 | -0.91±0.05  | 1.43±0.045  | -1.63±0.22  | 14.250±4.661  |
| 22  | B076 | -1.63±0.06   | 17.250±2.750 | -1.63±0.00  | 18.250±3.319 | -1.61±0.02  | 12.500±7.309  |
| 23  | B081 | -0.87±0.05   | 1.43±0.009  | -0.88±0.06  | 1.43±0.008  | -0.21±0.12  | 2.000±0.325  |
| 24  | B083 | -1.40±0.08   | 16.500±3.500 | -1.40±0.07  | 17.750±0.049 | -1.63±0.27  | 17.250±7.598  |
| 25  | B085 | -1.56±0.07   | 2.750±0.281  | -1.02±0.10  | 1.700±0.161  | -1.63±0.14  | 6.500±2.829  |
| 26  | B086 | -1.07±0.04   | 1.43±0.021  | -1.10±0.05  | 1.43±0.029  | -0.96±0.07  | 1.43±0.027  |
| 27  | B088 | -1.63±0.14   | 1.43±0.121  | -1.63±0.07  | 1.609±0.178  | -0.33±0.08  | 1.015±0.883  |
| 28  | B096 | -1.63±0.06   | 1.68±0.081  | -1.63±0.05  | 1.609±0.072  | -0.37±0.14  | 1.278±0.004  |
| 29  | B100 | -1.47±0.13   | 20.00±0.000 | -1.52±0.11  | 20.000±0.716 | -0.75±0.14  | 12.000±3.365  |
| No. | Name  | All Data [Fe/H] (dex) | All Data Age (Gyr) | Without WISE Data [Fe/H] (dex) | Without WISE Data Age (Gyr) | Without GALEX Data [Fe/H] (dex) | Without GALEX Data Age (Gyr) |
|-----|-------|-----------------------|--------------------|--------------------------------|-----------------------------|---------------------------------|-----------------------------|
| 30  | B101  | -0.84±0.05            | 1.43±0.00          | -1.63±0.09                    | 20.00±0.00                  | 0.06±0.12                       | 2.000±0.499                 |
| 31  | B103  | -0.64±0.09            | 1.43±0.016         | -0.62±0.10                    | 1.43±0.19                   | -0.31±0.10                      | 2.000±0.415                 |
| 32  | B107  | -0.88±0.05            | 1.43±0.007         | -1.63±0.07                    | 20.00±0.00                  | -0.09±0.14                      | 2.000±0.461                 |
| 33  | B110  | -1.41±0.05            | 20.000±0.00        | -1.42±0.04                    | 20.000±0.00                 | -0.66±0.13                      | 18.000±2.000                |
| 34  | B126  | -0.83±0.05            | 1.43±0.004         | -1.12±0.06                    | 1.43±0.016                  | -0.33±0.02                      | 1.43±0.002                  |
| 35  | B135  | -1.04±0.05            | 1.43±0.008         | -1.00±0.05                    | 1.43±0.029                  | -1.48±0.21                      | 14.250±5.430                |
| 36  | B147  | -0.82±0.08            | 20.000±0.00        | -0.88±0.07                    | 20.000±0.00                 | -0.25±0.10                      | 10.750±4.362                |
| 37  | B148  | -0.33±0.09            | 0.571±0.021        | -1.63±0.05                    | 1.609±0.066                 | 0.28±0.00                       | 0.719±0.110                 |
| 38  | B151  | -1.48±0.11            | 14.250±2.184       | -1.45±0.09                    | 17.000±3.969                | -1.25±0.13                      | 9.250±7.156                 |
| 39  | B153  | -0.34±0.06            | 1.43±0.004         | -0.76±0.07                    | 20.000±0.00                 | 0.17±0.10                       | 2.600±0.458                 |
| 40  | B158  | -1.40±0.05            | 20.000±0.00        | -1.40±0.05                    | 20.000±0.00                 | -0.84±0.14                      | 13.000±7.000                |
| 41  | B165  | -1.63±0.11            | 2.300±0.453        | -1.63±0.10                    | 2.300±0.367                 | -1.63±0.29                      | 2.200±3.282                 |
| 42  | B174  | -1.56±0.07            | 18.750±3.107       | -1.53±0.06                    | 20.000±2.831                | -1.18±0.17                      | 12.000±7.175                |
| 43  | B178  | -1.63±0.03            | 20.000±0.00        | -1.63±0.02                    | 20.000±0.00                 | -0.91±0.16                      | 3.500±2.372                 |
| 44  | B179  | -1.01±0.11            | 14.750±2.889       | -1.03±0.10                    | 14.750±2.751                | -0.60±0.14                      | 3.750±1.230                 |
| 45  | B181  | -0.72±0.04            | 1.43±0.004         | -0.74±0.04                    | 1.43±0.005                  | 0.27±0.01                       | 1.609±0.975                 |
| 46  | B182  | -1.14±0.04            | 1.43±0.035         | -1.12±0.05                    | 1.43±0.023                  | -1.08±0.17                      | 2.750±1.579                 |
| 47  | B193  | -0.82±0.07            | 20.000±0.00        | -0.82±0.06                    | 20.000±0.00                 | -0.58±0.09                      | 12.000±8.000                |
| 48  | B194  | -1.63±0.15            | 2.100±0.328        | -1.63±0.15                    | 2.000±0.363                 | -1.25±0.16                      | 1.700±0.258                 |
| 49  | B205  | -0.97±0.10            | 14.750±2.570       | -0.98±0.10                    | 14.750±2.944                | -0.54±0.11                      | 3.750±2.224                 |
| 50  | B206  | -1.37±0.04            | 20.000±0.00        | -1.37±0.03                    | 20.000±0.00                 | -0.65±0.10                      | 3.750±2.176                 |
| 51  | B207  | -1.63±0.04            | 18.250±3.152       | -1.63±0.04                    | 18.250±3.060                | -1.39±0.24                      | 6.750±3.194                 |
| 52  | B211  | -1.56±0.14            | 2.200±0.472        | -1.10±0.06                    | 1.43±0.152                  | -1.63±0.32                      | 2.750±3.817                 |
| 53  | B212  | -1.52±0.11            | 1.900±0.134        | -1.13±0.05                    | 1.43±0.019                  | -1.63±0.27                      | 2.750±3.999                 |
| 54  | B218  | -1.57±0.06            | 20.000±0.00        | -1.59±0.07                    | 20.000±0.00                 | -0.88±0.13                      | 13.000±7.000                |
| 55  | B224  | -0.42±0.05            | 0.905±0.031        | -0.79±0.05                    | 1.278±0.19                 | -1.24±0.30                      | 1.278±0.046                 |
| 56  | B225  | -0.80±0.05            | 20.000±0.00        | -0.82±0.07                    | 20.000±0.00                 | -0.19±0.11                      | 5.250±3.451                 |
| 57  | B229  | -0.79±0.06            | 1.278±0.014        | -1.63±0.00                    | 14.250±0.967                | -1.62±0.01                      | 3.500±1.490                 |
| 58  | B230  | -1.55±0.08            | 2.000±0.186        | -1.12±0.05                    | 1.43±0.115                  | -1.63±0.15                      | 4.750±2.832                 |
| No. | Name | All Data [Fe/H] (dex) | Age (Gyr) | Without WISE Data [Fe/H] (dex) | Age (Gyr) | Without GALEX Data [Fe/H] | Age (Gyr) |
|-----|------|-----------------------|-----------|--------------------------------|-----------|----------------------------|-----------|
| 59  | B232 | -1.36±0.12            | 1.609±0.95| -1.63±0.10                     | 2.000±0.19| -1.01±0.17                 | 1.278±0.007|
| 60  | B233 | -1.54±0.07            | 15.750±2.920| -0.88±0.04                     | 1.434±0.018| -0.38±0.02                | 14.000±5.608|
| 61  | B235 | -1.45±0.09            | 20.000±2.863| -0.17±0.07                     | 20.000±0.000| -0.69±0.014              | 17.500±2.500|
| 62  | B237 | -0.84±0.10            | 1.278±0.005| -0.81±0.08                     | 1.278±0.007| -1.27±0.012              | 1.609±0.169|
| 63  | B240 | -1.11±0.04            | 1.434±0.139| -1.05±0.05                     | 1.434±0.030| -1.48±0.023              | 5.000±5.196|
| 64  | B255 | -0.52±0.14            | 0.571±0.064| -0.63±0.16                     | 0.571±0.074| -0.19±0.020              | 0.719±0.138|
| 65  | B289 | -1.11±0.11            | 1.139±0.053| -0.89±0.09                     | 1.015±0.071| -1.13±0.15                | 1.139±0.101|
| 66  | B292 | -1.41±0.15            | 1.278±0.045| -1.63±0.16                     | 1.609±0.126| -0.33±0.003              | 1.015±0.012|
| 67  | B293 | -1.35±0.13            | 1.278±0.078| -1.41±0.13                     | 1.434±0.037| -1.25±0.016              | 1.278±0.055|
| 68  | B302 | -1.45±0.06            | 19.500±2.209| -1.43±0.05                     | 20.000±0.000| -1.17±0.18               | 11.000±2.068|
| 69  | B304 | -1.00±0.07            | 1.700±0.119| -0.96±0.06                     | 1.434±0.039| -1.39±0.024              | 5.000±6.408|
| 70  | B310 | -1.63±0.04            | 15.750±2.122| -0.97±0.05                     | 1.434±0.037| -1.62±0.28               | 14.250±3.750|
| 71  | B311 | -1.04±0.09            | 1.139±0.042| -1.63±0.06                     | 1.800±0.131| -1.26±0.37               | 1.278±0.041|
| 72  | B312 | -1.63±0.10            | 16.500±3.500| -1.61±0.09                     | 17.500±2.500| -1.48±0.27               | 14.250±3.750|
| 73  | B313 | -1.63±0.10            | 1.700±0.091| -1.63±0.07                     | 1.680±0.116| -1.44±0.22               | 9.000±7.777|
| 74  | B315 | -0.61±0.13            | 0.360±0.028| -0.33±0.15                     | 0.321±0.040| -0.65±0.14               | 0.404±0.057|
| 75  | B317 | -0.86±0.06            | 1.278±0.019| -1.01±0.07                     | 1.609±0.084| -0.30±0.16               | 1.015±0.111|
| 76  | B321 | 0.28±0.09             | 0.143±0.016| 0.28±0.00                      | 0.143±0.008| 0.07±0.011               | 0.028±0.002|
| 77  | B325 | -0.63±0.12            | 0.509±0.075| -0.64±0.08                     | 0.571±0.066| -1.32±0.20               | 2.750±1.514|
| 78  | B330 | -0.85±0.06            | 1.434±0.013| -0.92±0.06                     | 1.434±0.027| -0.05±0.18               | 1.700±0.493|
| 79  | B335 | -0.85±0.06            | 1.434±0.005| -1.01±0.07                     | 1.434±0.009| -0.90±0.20              | 3.750±3.500|
| 80  | B336 | -1.51±0.09            | 17.250±2.306| -0.86±0.05                     | 1.434±0.017| -0.25±0.14              | 6.750±5.245|
| 81  | B338 | -1.63±0.03            | 20.000±2.716| -1.63±0.03                     | 20.000±0.000| -1.25±0.22              | 6.750±3.024|
| 82  | B343 | -1.62±0.12            | 1.900±0.152| -1.14±0.06                     | 1.434±0.022| -1.62±0.01              | 3.500±1.579|
| 83  | B345 | -1.61±0.15            | 1.700±0.164| -1.58±0.13                     | 1.700±0.154| -1.63±0.40              | 2.750±3.968|
| 84  | B347 | -1.21±0.09            | 14.500±2.218| -0.68±0.03                     | 1.434±0.044| -1.05±0.16              | 12.000±7.761|
| 85  | B350 | -1.63±0.05            | 14.250±3.266| -0.94±0.05                     | 1.434±0.045| -1.63±0.26              | 14.250±5.109|
| 86  | B352 | -1.63±0.12            | 1.800±0.114| -1.58±0.05                     | 1.800±0.097| -1.63±0.00              | 2.750±1.071|
| 87  | B356 | -1.38±0.11            | 2.000±0.274| -1.63±0.05                     | 17.250±2.750| -1.61±0.23              | 6.500±4.180|
| No. | Name | [Fe/H] | Age | [Fe/H] | Age | [Fe/H] | Age |
|-----|------|--------|------|--------|------|--------|------|
|     |      | (dex)  | (Gyr) | (dex)  | (Gyr) | (dex)  | (Gyr) |
| 88  | B358 | -1.63±0.05 | 13.250±1.337 | -1.63±0.06 | 13.000±1.227 | -1.63±0.22 | 6.500±4.998 |
| 89  | B361 | -1.46±0.13 | 1.800±0.117 | -1.10±0.05 | 1.434±0.019 | -1.62±0.35 | 3.500±1.575 |
| 90  | B365 | -0.96±0.08 | 1.278±0.007 | -1.10±0.05 | 1.434±0.012 | -1.27±0.16 | 1.609±0.188 |
| 91  | B370 | -1.12±0.04 | 1.434±0.054 | -1.08±0.06 | 1.434±0.027 | -1.10±0.18 | 2.750±1.406 |
| 92  | B377 | -0.99±0.12 | 1.800±0.186 | -0.91±0.08 | 1.434±0.012 | -1.26±0.20 | 5.000±2.629 |
| 93  | B380 | -0.35±0.03 | 1.015±0.009 | -0.38±0.04 | 1.015±0.018 | -1.18±0.16 | 1.139±0.094 |
| 94  | B382 | -1.25±0.12 | 1.278±0.048 | -1.16±0.12 | 1.278±0.038 | -1.25±0.15 | 1.278±0.051 |
| 95  | B386 | -1.50±0.09 | 12.000±1.614 | -0.76±0.04 | 1.434±0.034 | -1.58±0.26 | 16.500±6.422 |
| 96  | B396 | -1.44±0.12 | 2.000±0.287 | -1.43±0.14 | 2.000±0.206 | -1.63±0.32 | 3.500±1.648 |
| 97  | B405 | -1.19±0.04 | 1.434±0.067 | -1.15±0.04 | 1.434±0.034 | -1.41±0.25 | 3.500±3.827 |
| 98  | B411 | -0.42±0.11 | 0.571±0.026 | -0.63±0.05 | 0.571±0.030 | -0.48±0.12 | 1.434±0.005 |
| 99  | B412 | -0.82±0.06 | 1.434±0.007 | -0.63±0.08 | 2.000±0.000 | 0.07±0.13 | 2.600±0.794 |
| 100 | B467 | -1.63±0.07 | 14.250±2.700 | -1.63±0.09 | 14.250±3.615 | -1.54±0.09 | 6.500±4.019 |
| 101 | B472 | -1.63±0.07 | 20.000±0.000 | -1.63±0.06 | 20.000±0.000 | -0.69±0.13 | 2.600±1.358 |
| 102 | B475 | -0.11±0.17 | 0.641±0.063 | -0.14±0.09 | 0.641±0.038 | -0.23±0.24 | 0.641±0.081 |
| 103 | B486 | -1.02±0.14 | 1.278±0.013 | -0.96±0.11 | 1.278±0.016 | -0.32±0.07 | 1.015±0.024 |
| 104 | G001 | -1.36±0.03 | 20.000±0.000 | -1.39±0.04 | 20.000±0.000 | -0.23±0.15 | 2.100±0.454 |
| 105 | G002 | -1.63±0.00 | 12.500±1.985 | -1.63±0.11 | 12.500±1.465 | -1.59±0.32 | 10.000±7.986 |
| 106 | G085 | 0.19±0.09 | 0.128±0.002 | 0.28±0.01 | 0.128±0.005 | 0.28±0.05 | 0.047±0.003 |
| 107 | G260 | -1.15±0.14 | 1.139±0.043 | -0.95±0.13 | 1.139±0.029 | -1.23±0.15 | 1.139±0.118 |
| 108 | G327 | -1.62±0.14 | 4.000±1.005 | -1.52±0.12 | 4.000±0.697 | -1.63±0.25 | 3.500±3.375 |
| 109 | G353 | -1.08±0.13 | 1.139±0.053 | -0.99±0.15 | 1.139±0.078 | -1.19±0.17 | 1.139±0.079 |
| 110 | VDB0 | -0.33±0.12 | 0.064±0.011 | -0.10±0.21 | 0.055±0.008 | -0.84±0.61 | 0.055±0.017 |
| 111 | B011D | -0.83±0.03 | 1.434±0.001 | -0.98±0.04 | 1.434±0.002 | -0.28±0.02 | 20.000±0.727 |
| 112 | B108D | 0.28±0.00 | 0.143±0.005 | 0.28±0.00 | 0.143±0.014 | -0.28±0.00 | 0.641±0.092 |
| 113 | B110D | -1.11±0.07 | 1.434±0.014 | -1.63±0.00 | 1.680±0.148 | -1.03±0.08 | 1.434±0.012 |
| 114 | B134D | 0.28±0.00 | 0.045±0.003 | 0.28±0.00 | 0.045±0.003 | 0.07±0.16 | 0.571±0.100 |
| 115 | B165D | -0.43±0.10 | 0.571±0.019 | -0.59±0.09 | 0.571±0.015 | -0.64±0.13 | 1.434±0.005 |
| 116 | B167D | -1.12±0.05 | 1.434±0.040 | -1.11±0.05 | 1.434±0.033 | -1.06±0.09 | 1.434±0.014 |
| No. | Name  | All Data | Without WISE Data | Without GALEX Data |
|-----|-------|----------|-------------------|-------------------|
|     |       | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) |
| 117 | B233D | $-1.07^{+0.03}_{-0.04}$ | $1.434^{+0.008}_{-0.004}$ | $-1.63^{+0.04}_{-0.00}$ | $1.680^{+0.049}_{-0.112}$ | $-0.36^{+0.12}_{-0.10}$ | $1.434^{+0.010}_{-0.004}$ |
| 118 | B256D | $-0.96^{+0.05}_{-0.04}$ | $0.010^{+0.001}_{-0.000}$ | $-0.93^{+0.05}_{-0.05}$ | $0.010^{+0.000}_{-0.000}$ | $-0.62^{+0.16}_{-0.11}$ | $0.015^{+0.001}_{-0.002}$ |
| 119 | B344D | $-1.63^{+0.05}_{-0.00}$ | $20.000^{+0.000}_{-1.525}$ | $-1.63^{+0.04}_{-0.00}$ | $20.000^{+0.000}_{-1.242}$ | $-0.71^{+0.14}_{-0.21}$ | $4.250^{+2.916}_{-1.827}$ |
| 120 | BA11  | $-1.63^{+0.08}_{-0.00}$ | $20.000^{+0.000}_{-1.362}$ | $-1.63^{+0.06}_{-0.00}$ | $20.000^{+0.000}_{-1.151}$ | $-0.62^{+0.14}_{-0.17}$ | $3.500^{+2.917}_{-1.244}$ |
| 121 | BA22  | $-1.03^{+0.11}_{-0.05}$ | $1.434^{+0.009}_{-0.005}$ | $-0.49^{+0.11}_{-0.14}$ | $0.571^{+0.052}_{-0.022}$ | $-0.38^{+0.16}_{-0.10}$ | $1.434^{+0.013}_{-0.005}$ |
| 122 | BH05  | $-0.67^{+0.13}_{-0.04}$ | $0.015^{+0.001}_{-0.000}$ | $-0.75^{+0.14}_{-0.13}$ | $0.015^{+0.001}_{-0.000}$ | $-0.72^{+0.15}_{-0.10}$ | $0.015^{+0.001}_{-0.000}$ |
| 123 | SK107B| $-0.88^{+0.04}_{-0.05}$ | $1.434^{+0.003}_{-0.002}$ | $-1.63^{+0.00}_{-0.00}$ | $20.000^{+0.000}_{-2.56}$ | $0.28^{+0.00}_{-0.01}$ | $1.609^{+0.003}_{-0.004}$ |
Table 3. Ages and Metallicities Derived from the SED fitting with GALEV models and Kroupa IMF.

| No. | Name  | All Data [Fe/H] (dex) | All Data Age [Gyr] | Without WISE Data [Fe/H] (dex) | Without WISE Data Age [Gyr] | Without GALEX Data [Fe/H] (dex) | Without GALEX Data Age [Gyr] |
|-----|-------|-----------------------|--------------------|---------------------------------|-----------------------------|---------------------------------|-------------------------------|
| 1   | B003  | -1.70±0.21            | 2.692±0.460       | -1.70±0.22                      | 2.692±0.410                  | -1.70±0.09                      | 15.912±0.088                  |
| 2   | B009  | -1.52±0.15            | 3.268±0.398       | -1.34±0.14                      | 2.976±0.375                  | -1.70±0.35                      | 1.220±14.071                  |
| 3   | B010  | -1.38±0.12            | 1.792±0.142       | -1.45±0.14                      | 1.836±0.125                  | -1.56±0.14                      | 4.912±11.088                  |
| 4   | B011  | -0.95±0.06            | 1.372±0.231       | -0.95±0.06                      | 1.304±0.254                  | -1.13±0.18                      | 3.312±7.784                   |
| 5   | B012  | -1.70±0.07            | 1.764±0.102       | -1.70±0.12                      | 1.820±0.090                  | -1.70±0.08                      | 1.592±0.237                   |
| 6   | B019  | -0.92±0.04            | 1.416±0.151       | -0.95±0.04                      | 1.428±0.147                  | -1.17±0.12                      | 15.256±7.744                  |
| 7   | B020  | -0.95±0.07            | 1.340±0.176       | -0.95±0.04                      | 1.340±0.165                  | -1.20±0.15                      | 15.956±4.044                  |
| 8   | B022  | -1.70±0.00            | 1.848±0.232       | -1.70±0.00                      | 1.948±0.177                  | -1.70±0.00                      | 1.000±0.266                   |
| 9   | B023  | -1.09±0.09            | 1.908±0.235       | -0.99±0.06                      | 1.780±0.196                  | -1.31±0.16                      | 14.676±3.324                  |
| 10  | B025  | -1.70±0.19            | 2.040±0.342       | -1.34±0.14                      | 1.876±0.147                  | -1.70±0.09                      | 15.860±2.960                  |
| 11  | B027  | -1.70±0.00            | 2.020±0.104       | -1.70±0.00                      | 2.020±0.078                  | -1.70±0.00                      | 1.000±0.376                   |
| 12  | B038  | -1.70±0.11            | 1.260±0.039       | -1.59±0.11                      | 1.260±0.037                  | -1.31±0.18                      | 5.292±10.708                  |
| 13  | B046  | -1.31±0.22            | 0.496±0.070       | -0.03±0.06                      | 0.512±0.087                  | -0.03±0.24                      | 0.500±0.050                   |
| 14  | B047  | -1.70±0.00            | 1.828±0.314       | -1.70±0.00                      | 1.864±0.355                  | -1.70±0.00                      | 1.592±0.105                   |
| 15  | B048  | -1.59±0.25            | 1.620±0.039       | -1.59±0.11                      | 1.620±0.037                  | -1.31±0.18                      | 5.292±10.708                  |
| 16  | B049  | 0.01±0.06             | 0.496±0.024       | -0.03±0.06                      | 0.512±0.087                  | -0.03±0.24                      | 0.500±0.050                   |
| 17  | B058  | -1.31±0.10            | 1.812±0.114       | -1.02±0.09                      | 1.260±0.214                  | -1.56±0.14                      | 15.460±0.540                  |
| 18  | B061  | -0.95±0.17            | 0.496±0.070       | -0.89±0.20                      | 0.500±0.040                  | -1.41±0.13                      | 13.984±12.178                |
| 19  | B064  | -1.27±0.17            | 1.176±0.075       | -1.27±0.15                      | 1.176±0.067                  | -1.52±0.38                      | 1.224±0.988                   |
| 20  | B065  | -1.70±0.08            | 3.396±0.510       | -1.59±0.11                      | 3.276±0.445                  | -1.70±0.00                      | 1.688±0.236                   |
| 21  | B074  | -1.63±0.15            | 2.232±0.239       | -1.49±0.13                      | 2.076±0.251                  | -1.70±0.00                      | 3.240±11.530                  |
| 22  | B076  | -1.59±0.11            | 1.880±0.243       | -1.45±0.24                      | 1.756±0.518                  | -1.70±0.00                      | 4.788±2.994                   |
| 23  | B081  | -0.56±0.06            | 0.912±0.044       | -0.40±0.00                      | 0.324±0.026                  | 0.02±0.11                      | 1.088±0.104                   |
| 24  | B083  | -1.31±0.15            | 2.292±0.320       | -1.17±0.13                      | 2.056±0.171                  | -1.70±0.00                      | 7.984±6.010                   |
| 25  | B085  | -1.70±0.07            | 1.892±0.390       | -1.70±0.12                      | 1.968±0.406                  | -1.70±0.08                      | 1.588±0.258                   |
| 26  | B086  | -1.31±0.12            | 1.188±0.064       | -1.59±0.11                      | 1.440±0.224                  | -1.17±0.33                      | 1.184±0.099                   |
| 27  | B088  | -1.70±0.05            | 0.972±0.046       | -1.70±0.15                      | 0.992±0.050                  | -1.70±0.06                      | 1.000±0.031                   |
| 28  | B096  | -0.95±0.21            | 0.504±0.060       | -1.02±0.25                      | 0.500±0.073                  | -1.34±0.19                      | 1.596±0.490                   |
| 29  | B100  | -0.99±0.12            | 1.260±0.094       | -1.02±0.10                      | 1.260±0.276                  | -1.09±0.14                      | 15.988±3.311                  |
Table 3—Continued

| No. | Name | All Data | | Without WISE Data | | Without GALEX Data |
|-----|------|----------|----------|-------------------|----------|-------------------|
|     | [Fe/H] | Age (Gyr) | [Fe/H] | Age (Gyr) | [Fe/H] | Age (Gyr) |
|-----|--------|-----------|--------|-----------|--------|-----------|
| 30  | B101   |           |        |           |        |           |
| 31  | B103   |           |        |           |        |           |
| 32  | B107   |           |        |           |        |           |
| 33  | B110   |           |        |           |        |           |
| 34  | B126   |           |        |           |        |           |
| 35  | B135   |           |        |           |        |           |
| 36  | B147   |           |        |           |        |           |
| 37  | B148   |           |        |           |        |           |
| 38  | B151   |           |        |           |        |           |
| 39  | B153   |           |        |           |        |           |
| 40  | B158   |           |        |           |        |           |
| 41  | B165   |           |        |           |        |           |
| 42  | B174   |           |        |           |        |           |
| 43  | B178   |           |        |           |        |           |
| 44  | B179   |           |        |           |        |           |
| 45  | B181   |           |        |           |        |           |
| 46  | B182   |           |        |           |        |           |
| 47  | B193   |           |        |           |        |           |
| 48  | B194   |           |        |           |        |           |
| 49  | B205   |           |        |           |        |           |
| 50  | B206   |           |        |           |        |           |
| 51  | B207   |           |        |           |        |           |
| 52  | B211   |           |        |           |        |           |
| 53  | B212   |           |        |           |        |           |
| 54  | B218   |           |        |           |        |           |
| 55  | B224   |           |        |           |        |           |
| 56  | B225   |           |        |           |        |           |
| 57  | B229   |           |        |           |        |           |
| 58  | B230   |           |        |           |        |           |
| No. | Name  | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) |
|-----|-------|--------------|-----------|--------------|-----------|--------------|-----------|
| 59  | B232  | −1.70±0.04   | 1.584±0.066 | −1.70±0.08   | 1.584±0.112 | −1.70±0.08   | 1.000±0.036 |
| 60  | B233  | −1.41±0.12   | 1.976±0.218 | −1.20±0.08   | 1.812±0.122 | −1.70±0.20   | 6.252±9.748  |
| 61  | B235  | −0.99±0.10   | 1.320±0.368 | −0.99±0.09   | 1.320±0.276 | −0.95±0.13   | 7.500±5.000  |
| 62  | B237  | −1.70±0.06   | 0.800±0.522 | −1.70±0.07   | 1.896±0.487 | −1.70±0.00   | 1.000±0.173  |
| 63  | B240  | −1.70±0.12   | 1.784±0.136 | −1.41±0.11   | 1.564±0.147 | −1.70±0.17   | 1.740±0.382  |
| 64  | B255  | −1.13±0.26   | 0.592±0.124 | −1.17±0.27   | 0.600±0.106 | −1.17±0.29   | 0.684±0.250  |
| 65  | B289  | −1.70±0.06   | 1.000±0.018 | −1.70±0.17   | 0.000±0.000 | −1.70±0.05   | 0.120±0.005  |
| 66  | B292  | −1.70±0.06   | 0.900±0.024 | −1.66±0.02   | 1.000±0.070 | −1.70±0.00   | 0.620±0.148  |
| 67  | B293  | −1.70±0.08   | 1.000±0.026 | −1.63±0.019  | 0.000±0.048 | −1.70±0.05   | 0.508±0.036  |
| 68  | B302  | −1.24±0.10   | 1.932±0.134 | −0.93±0.05   | 1.260±0.216 | −1.59±0.19   | 14.464±1.536 |
| 69  | B304  | −1.70±0.13   | 1.984±0.352 | −1.45±0.13   | 1.880±0.132 | −1.70±0.19   | 1.800±0.487  |
| 70  | B310  | −1.70±0.17   | 1.956±0.244 | −1.41±0.13   | 1.788±0.132 | −1.70±0.16   | 3.596±12.404 |
| 71  | B311  | −1.70±0.06   | 1.000±0.019 | −1.52±0.19   | 1.000±0.048 | −1.70±0.05   | 0.628±0.144  |
| 72  | B312  | −1.49±0.16   | 1.916±0.235 | −1.09±0.12   | 1.264±0.400 | −1.70±0.21   | 5.540±1.160  |
| 73  | B313  | −1.70±0.10   | 1.132±0.062 | −1.70±0.09   | 1.136±0.063 | −1.70±0.01   | 1.166±0.005  |
| 74  | B315  | −1.70±0.04   | 0.504±0.034 | −1.70±0.09   | 0.504±0.049 | −1.70±0.14   | 0.116±0.001  |
| 75  | B317  | −1.70±0.06   | 1.860±0.111 | −1.70±0.10   | 1.940±0.204 | −1.70±0.10   | 1.000±0.061  |
| 76  | B321  | −0.38±0.10   | 0.120±0.003 | −0.38±0.14   | 0.120±0.006 | −0.35±0.06   | 0.116±0.003  |
| 77  | B325  | −1.70±0.30   | 0.396±0.047 | −1.06±0.25   | 0.480±0.067 | −1.70±0.16   | 1.592±0.165  |
| 78  | B327  | −0.42±0.09   | 0.040±0.004 | −0.38±0.15   | 0.040±0.004 | −0.56±0.25   | 0.024±0.004  |
| 79  | B330  | −1.02±0.11   | 1.472±0.247 | −1.13±0.13   | 1.268±0.409 | −0.70±0.21   | 1.644±1.220  |
| 80  | B337  | −1.24±0.12   | 1.844±0.130 | −0.99±0.08   | 1.348±0.244 | −1.45±0.21   | 4.136±11.864 |
| 81  | B338  | −1.38±0.10   | 1.467±0.217 | −1.27±0.10   | 1.264±0.241 | −1.70±0.15   | 5.224±10.776 |
| 82  | B343  | −1.70±0.06   | 1.584±0.103 | −1.70±0.14   | 1.524±0.224 | −1.70±0.18   | 1.056±0.263  |
| 83  | B345  | −1.70±0.20   | 1.076±0.071 | −1.52±0.19   | 1.072±0.070 | −1.70±0.18   | 1.040±0.074  |
| 84  | B347  | −1.09±0.10   | 2.432±0.243 | −0.95±0.07   | 2.108±0.184 | −1.45±0.20   | 9.996±6.865  |
| 85  | B350  | −1.70±0.17   | 2.040±0.330 | −1.49±0.14   | 1.936±0.194 | −1.70±0.14   | 3.300±10.104 |
| 86  | B352  | −1.49±0.15   | 1.024±0.049 | −1.27±0.13   | 1.000±0.049 | −1.70±0.00   | 1.000±0.336  |
| 87  | B356  | −1.70±0.09   | 1.812±0.201 | −1.70±0.22   | 1.924±0.275 | −1.70±0.08   | 1.640±1.857  |
| No. | Name  | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) | [Fe/H] (dex) | Age (Gyr) |
|-----|-------|-------------|-----------|-------------|-----------|-------------|-----------|
| 88  | B358  | −1.70 ± 0.09 | 3.238 ± 0.169 | −1.70 ± 0.15 | 2.372 ± 0.138 | −1.70 ± 0.14 | 1.592 ± 1.499 |
| 89  | B361  | −1.70 ± 0.10 | 1.592 ± 0.119 | −1.59 ± 0.17 | 1.536 ± 0.199 | −1.70 ± 0.16 | 1.056 ± 0.292 |
| 90  | B365  | −1.70 ± 0.07 | 1.652 ± 0.094 | −1.70 ± 0.12 | 1.764 ± 0.108 | −1.70 ± 0.13 | 1.000 ± 0.277 |
| 91  | B370  | −1.63 ± 0.15 | 1.520 ± 0.218 | −1.17 ± 0.12 | 1.096 ± 0.066 | −1.70 ± 0.30 | 1.196 ± 0.468 |
| 92  | B377  | −1.70 ± 0.20 | 2.236 ± 0.546 | −0.81 ± 0.14 | 1.116 ± 0.077 | −1.70 ± 0.19 | 3.336 ± 10.368 |
| 93  | B380  | −1.70 ± 0.02 | 3.052 ± 0.333 | −1.70 ± 0.03 | 3.004 ± 0.029 | −1.70 ± 0.04 | 0.504 ± 0.140 |
| 94  | B382  | −1.70 ± 0.08 | 1.000 ± 0.043 | −1.70 ± 0.04 | 1.584 ± 0.078 | −1.70 ± 0.04 | 1.000 ± 0.100 |
| 95  | B386  | −1.41 ± 0.13 | 2.504 ± 0.346 | −1.24 ± 0.11 | 2.333 ± 0.193 | −1.70 ± 0.19 | 5.888 ± 10.112 |
| 96  | B396  | −1.70 ± 0.11 | 1.720 ± 0.202 | −1.70 ± 0.13 | 1.796 ± 0.215 | −1.70 ± 0.09 | 1.592 ± 0.105 |
| 97  | B405  | −1.70 ± 0.07 | 1.576 ± 0.073 | −1.45 ± 0.16 | 1.124 ± 0.056 | −1.70 ± 0.16 | 1.624 ± 1.791 |
| 98  | B411  | −0.42 ± 0.12 | 0.356 ± 0.036 | −0.70 ± 0.14 | 0.316 ± 0.010 | −0.18 ± 0.12 | 0.796 ± 0.111 |
| 99  | B412  | −1.02 ± 0.12 | 1.280 ± 0.379 | −1.20 ± 0.17 | 1.260 ± 0.116 | −0.49 ± 0.15 | 5.836 ± 5.146 |
| 100 | B467  | −1.70 ± 0.14 | 2.136 ± 0.329 | −1.63 ± 0.07 | 2.108 ± 0.194 | −1.70 ± 0.06 | 15.868 ± 1.387 |
| 101 | B472  | −1.20 ± 0.11 | 1.260 ± 0.256 | −1.17 ± 0.08 | 1.260 ± 0.189 | −1.34 ± 0.16 | 4.728 ± 9.981 |
| 102 | B475  | −1.70 ± 0.17 | 1.592 ± 0.248 | −1.06 ± 0.20 | 1.000 ± 0.045 | −1.24 ± 0.30 | 0.588 ± 0.216 |
| 103 | B486  | −1.70 ± 0.07 | 1.584 ± 0.149 | −1.70 ± 0.11 | 1.584 ± 0.200 | −1.70 ± 0.12 | 0.508 ± 0.507 |
| 104 | G001  | −0.92 ± 0.05 | 1.488 ± 0.152 | −0.92 ± 0.05 | 1.428 ± 0.137 | −0.70 ± 0.17 | 2.056 ± 0.790 |
| 105 | G002  | −1.63 ± 0.10 | 2.400 ± 0.324 | −1.45 ± 0.15 | 2.260 ± 0.223 | −1.70 ± 0.10 | 15.860 ± 1.410 |
| 106 | G085  | −0.46 ± 0.08 | 0.112 ± 0.004 | −0.31 ± 0.08 | 0.112 ± 0.004 | 0.15 ± 0.10 | 0.048 ± 0.009 |
| 107 | G260  | −1.70 ± 0.05 | 1.000 ± 0.047 | −1.70 ± 0.07 | 1.000 ± 0.049 | −1.70 ± 0.06 | 0.116 ± 0.002 |
| 108 | G327  | −1.70 ± 0.04 | 3.172 ± 0.428 | −1.70 ± 0.08 | 3.440 ± 0.340 | −1.70 ± 0.15 | 1.012 ± 0.600 |
| 109 | G353  | −1.70 ± 0.07 | 1.000 ± 0.023 | −1.70 ± 0.18 | 1.000 ± 0.043 | −1.70 ± 0.04 | 0.508 ± 0.029 |
| 110 | VDB0  | −0.42 ± 0.05 | 0.068 ± 0.009 | −0.38 ± 0.11 | 0.064 ± 0.014 | −1.13 ± 0.13 | 0.040 ± 0.023 |
| 111 | B011D | 0.40 ± 0.01 | 0.292 ± 0.011 | 0.40 ± 0.04 | 0.264 ± 0.017 | 0.40 ± 0.01 | 1.588 ± 0.009 |
| 112 | B108D | −0.85 ± 0.39 | 0.156 ± 0.026 | −1.24 ± 0.34 | 0.148 ± 0.031 | −0.28 ± 0.29 | 0.472 ± 0.147 |
| 113 | B110D | −1.06 ± 0.29 | 0.736 ± 0.120 | −1.70 ± 0.19 | 1.104 ± 0.074 | −1.41 ± 0.28 | 1.152 ± 0.835 |
| 114 | B134D | 0.11 ± 0.01 | 0.064 ± 0.001 | 0.18 ± 0.11 | 0.052 ± 0.003 | −1.13 ± 0.23 | 0.200 ± 0.192 |
| 115 | B165D | −0.70 ± 0.07 | 0.500 ± 0.021 | −0.70 ± 0.09 | 0.500 ± 0.022 | −0.60 ± 0.20 | 1.612 ± 0.297 |
| 116 | B167D | −1.34 ± 0.16 | 1.128 ± 0.073 | −1.31 ± 0.15 | 1.128 ± 0.074 | −1.38 ± 0.34 | 1.108 ± 0.787 |
| No. | Name  | All Data | Without WISE Data | Without GALEX Data |
|-----|-------|----------|-------------------|--------------------|
|     |       | [Fe/H]   | Age (dex)         | [Fe/H]             | Age (Gyr)          | [Fe/H]             | Age (Gyr)          |
| 117 | B233D | $0.29^{+0.04}_{-0.06}$ | $0.276^{+0.015}_{-0.019}$ | $-0.24^{+0.09}_{-0.10}$ | $0.400^{+0.035}_{-0.016}$ | $0.40^{+0.00}_{-0.10}$ | $0.616^{+0.147}_{-0.120}$ |
| 118 | B256D | $-0.85^{+0.16}_{-0.19}$ | $0.016^{+0.000}_{-0.000}$ | $-0.70^{+0.04}_{-0.22}$ | $0.016^{+0.000}_{-0.000}$ | $-0.56^{+0.12}_{-0.11}$ | $0.016^{+0.000}_{-0.001}$ |
| 119 | B344D | $-1.34^{+0.18}_{-0.21}$ | $1.260^{+0.170}_{-0.046}$ | $-1.34^{+0.19}_{-0.19}$ | $1.260^{+0.137}_{-0.038}$ | $-1.38^{+0.18}_{-0.18}$ | $12.024^{+3.976}_{-8.509}$ |
| 120 | BA11  | $-1.24^{+0.16}_{-0.21}$ | $1.260^{+0.182}_{-0.044}$ | $-1.24^{+0.16}_{-0.19}$ | $1.260^{+0.146}_{-0.037}$ | $-1.34^{+0.20}_{-0.19}$ | $8.744^{+7.256}_{-4.996}$ |
| 121 | BA22  | $0.26^{+0.11}_{-0.09}$ | $0.232^{+0.034}_{-0.027}$ | $-0.70^{+0.18}_{-0.09}$ | $0.316^{+0.016}_{-0.009}$ | $0.36^{+0.04}_{-0.12}$ | $0.720^{+0.147}_{-0.152}$ |
| 122 | BH05  | $-0.74^{+0.11}_{-0.19}$ | $0.016^{+0.000}_{-0.000}$ | $-0.85^{+0.17}_{-0.25}$ | $0.016^{+0.000}_{-0.000}$ | $-0.63^{+0.11}_{-0.22}$ | $0.016^{+0.000}_{-0.001}$ |
| 123 | SK107B| $0.40^{+0.00}_{-0.01}$ | $0.080^{+0.000}_{-0.001}$ | $0.40^{+0.04}_{-0.04}$ | $0.144^{+0.015}_{-0.018}$ | $0.33^{+0.05}_{-0.07}$ | $1.584^{+0.152}_{-0.049}$ |
Fig. 1.— Comparisons of metallicity fit with Padova 2000 evolutionary track and Chabrier (2003) IMF of Bruzual & Charlot (2003) model and that from literature works: Chen et al. (2016) (Top Left Panel); Caldwell et al. (2011) (Top Right Panel); PBH spectroscopies (Perrett et al. 2002; Barmby et al. 2000; Huchra et al. 1991) (Bottom Left Panel); Fan et al. (2010) (Bottom Right Panel). The dashed lines represent the best linear fits.
Fig. 2.— The same as Figure 1 but for GALEV models of Kroupa IMF. The dashed lines represent the best linear fits.
Fig. 3.— The same as Figure 1, but for comparisons of the ages fit with Padova 2000 evolutionary track and Chabrier (2003) IMF of Bruzual & Charlot (2003) model and that from literature works: Chen et al. (2016) (Top Left Panel); Caldwell et al. (2011) (Top Right Panel); Wang et al. (2010) (Bottom Left Panel); Fan et al. (2010) (Bottom Right Panel). The dashed lines represent the best linear fits.
Fig. 4.— The same as Figure 2 but for GALEV models of Kroupa IMF. The dashed lines represent the best linear fits.
Fig. 5.— Comparisons of metallicity derived from the Bruzual & Charlot (2003) models of Padova 1994/Padova 2000 evolutionary tracks (Top Panels) and IMFs of Chabrier (2003)/Salpeter (1955) (Bottom panels). The photometry of all bands are used for the fitting. The dashed lines represent the best linear fits.
Fig. 6.— Same as Figure 5 but for the ages, which are derived from evolutionary tracks of Padova 1994/Padova 2000 and IMFs of Chabrier (2003) / Salpeter (1955) of the Bruzual & Charlot (2003) models. The photometry of all bands are used for the fitting. The dashed lines represent the best linear fits.
Fig. 7.— Comparisons of metallicity fitted from the BC03 models with photometry of all bands and that without GALEX data (LEFT PANEL) and that without WISE data (RIGHT PANEL). The Padova 2000 evolutionary track and Chabrier (2003) IMF are applied. The dashed lines represent the best linear fits.
Fig. 8.— Comparisons of ages fitted from the BC03 models with photometry of all bands and that without GALEX data (LEFT PANEL) and that without WISE data (RIGHT PANEL). The Padova 2000 evolutionary track and Chabrier (2003) IMF are applied. The dashed lines represent the best linear fits.
Fig. 9.— Same as Figure 5 but for galev models of Kroupa/Scalo/Salpeter (1955) IMFs. The dashed lines represent the best linear fits.

Fig. 10.— Same as Figure 6 but for galev models with IMFs of Kroupa/Scalo/Salpeter (1955). The dashed lines represent the best linear fits.
Fig. 11.— Same as Figure 7 but for galev models of Kroupa IMF with photometry of all bands and that without GALEX data (Left Panel) and that without WISE data (Right Panel). The dashed lines represent the best linear fits.

Fig. 12.— Same as Figure 8 but for galev models of Kroupa IMF with photometry of all bands and that without GALEX data (Left Panel) and that without WISE data (Right Panel). The dashed lines represent the best linear fits.