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Reanalysis of 24 Nearby Open Clusters using Gaia data

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Abstract. We have developed a fully automated cluster characterization pipeline, which simultaneously determines cluster membership and fits the fundamental cluster parameters: distance, reddening, and age. We present results for 24 established clusters and compare them to literature values. Given the large amount of stellar data for clusters available from Gaia DR2 in 2018, this pipeline will be beneficial to analyzing the parameters of open clusters in our Galaxy.

Keywords. open clusters and associations: general

Open clusters are gravitationally bound groups of young stars located in the disk of the Milky Way, making them excellent objects for studying stellar evolution and the Galactic disk. The fundamental cluster parameters can be determined from fitting isochrones to the cluster color-magnitude diagram (CMD). In anticipation of the large amount of stellar data from Gaia, we have developed an automated pipeline to simultaneously determine cluster membership and fit mean cluster parameters: distance d, reddening $E(B-V)$, and age $\log t$. We use a χ^2 minimization to fit isochrones to the photometric observations of candidate cluster members. Our data set is comprised of ASCC-2.5 BV-, 2MASS JHK_s-, and Gaia DR1 G-band photometry, as well as TGAS proper motions and parallaxes.

The pipeline first determines cluster membership through proper motion and parallax selections. The proper motion selection begins by computing the weighted mean cluster proper motion ($\bar{\mu}_{\rm cluster}$) using membership probabilities from the Milky Way Star Clusters (MWSC) catalog (Kharchenko *et al.* 2013). Guided by the astrometric accuracy of TGAS, all stars within 2 mas/yr of $\bar{\mu}_{\rm cluster}$ are selected as cluster members, as well as stars within 5 mas/yr, if $\bar{\mu}_{\rm cluster}$ lies within the 3σ proper motion error ellipse of the star. This selection is iterated with a new $\bar{\mu}_{\rm cluster}$ until membership is unchanged. Next, the weighted mean cluster parallax ($\bar{\pi}_{\rm cluster}$) is computed for the proper motion-selected members. Cluster members are defined as those stars for which $\bar{\pi}_{\rm cluster}$ lies within the 3σ parallax error of the star. Similarly, the parallax selection is iterated until membership is unchanged.

Next is a photometric selection, where the zero-age main sequence (ZAMS) is fitted to the photometric observations of the astrometrically-selected cluster stars to obtain initial cluster $E(B-V)$ and d. The evolved members of the cluster, if any, are identified and down weighted. With highly probable cluster members, all isochrones in our set (Bressan *et al.* (2012) with $Z = Z_\odot$) are then fitted to the cluster photometry , where stellar binaries are accounted for with an 0.1 mag offset in all passbands. The isochrone

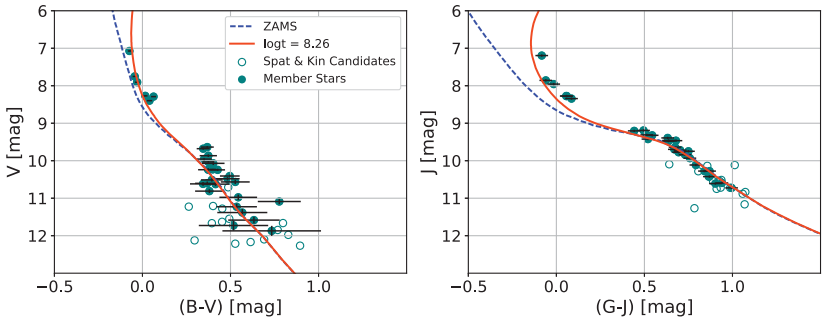

Figure 1. CMDs for Blanco 1 with fitted isochrone (log $t = 8.26$, $E(B-V) = 0.044 \pm 0.012$ mag, $d = 258 \pm 3$ pc).

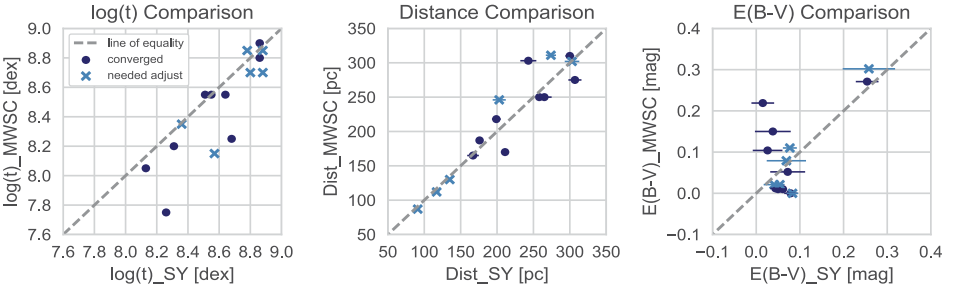

Figure 2. Comparison of cluster parameter results from this work (SY) to the MWSC.

yielding the minimum reduced χ^2 is selected and the star with the largest χ^2 contribution is removed. This process is repeated, starting with the photometric selection, until a reduced $\chi^2 < 5$ is achieved, yielding the cluster's final age, $E(B-V)$, and d. In Fig. 1, we illustrate the result of our fitting procedure with two CMDs for the cluster Blanco 1.

We have analyzed 24 nearby clusters with our automated pipeline. Parameter estimates were returned for 15 clusters, of which 9 converged unaided and 6 converged after individual adjustments. The remaining 9 clusters contained too few members to do a proper fit. In Fig. 2, we compare our fitted parameters for 15 clusters to those given in the MWSC. Six of our 15 clusters were also explored by the Gaia Collaboration, van Leeuwen *et al.* (2017). A comparison of the parallaxes of these six clusters gave a mean difference of 0.26 ± 0.15 mas. Our next steps include refining the selection criteria in the pipeline and adding HSOY (Altmann *et al.* 2017) proper motions and photometry.

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