Draft version April 15, 2022
Typeset using LaTeX **twocolumn** style in AASTeX631

Pathfinding with the Old Breed:

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ABSTRACT

Keywords: Open Clusters — Galactic Tracing — Galactic Disk — MIST Isochrone Fitting

This work is dedicated to my mentor and my friend Noel White, (1951-2021).

1. INTRODUCTION

Open clusters have been shown to be an integral part of the astronomers toolbox, readily lending themselves as stellar laboratories. Open clusters are classified as a group of stars around the same age and loosely bound through mutual gravitation. Their similar age allows for in depth observation of the stellar evolution. Through this many attributes of the stellar population can be inferred. As clusters span age ranges from a X to X, many have been present since formation of the disk itself. Through this if clusters of varying ages are examined it's possible to trace out the evolution of the milky way.

Mapping the milky way has always been difficult given the vantage point it can be observed from. This makes it quite difficult to appreciate the shape and dimensions of the milky way. Some of the pioneering studies such as Herschel (1785); Shapley (1918) and Trumpler (1930) first outline the use of open clusters to map the galaxy. Following with studies like Becker & Fenkart (1970) which pathed the spiral arms of the milky way using open clusters and numerous studies by van den Bergh (1958) which explore the evolution of the galaxies scale height. To more recent studies by X

While the precision and accuracy of cluster age estimates are tied to the quality of the observational data and theoretical models the process of estimating cluster age through use of colour-magnitude diagrams is relativity straightforward and been shown to be tried and true. Even early open cluster catalogues like X and X included distance estimates while more recent catalogues like X and X have provided other parameters such as age, metallicity and excess colour. Furthermore with the second data release from GAIA (X) presents the most in-depth all sky astrometric and photometric study to date.
This increase in available data has allowed for the characterisation of open clusters on mass adding to catalogues such as WEBDA. Determination of all open clusters identified by Gaia is an ongoing task and is being automated using modern techniques and machine learning as shown in studies by X and X.

This study used the 1.25 m optical telescope at the Calar Alto Observatory (CAHA) to observe four open clusters from the WEBDA catalogue. The aim of this work was to classify the four observed clusters and infer details of each cluster. Then use this observational cluster classification in tandem with other open clusters from the WEBDA catalogue to trace the paths of clusters in the galactic disk studying both its structure and evolution.

1.1. *Open Cluster Types*

As open clusters span many different distribtuions in both density, size and stellar constituents. Open clusters can contain large stellar agglomerations to just a handfull of stars. While classification systems can vary based on the context of the study the scheme coined by Trumpler (1930) sees promeinant use.
This scheme classifies cluster based on three factors of the stellar population. a) their range of brightness, b) degree of concerntration and c) star population in the cluster. The details of this classification scheme can be seen in table 1.

2. OBSERVATIONS

2.1. *Target Selection*

2.2. *Photometry*

Table 1. Trumpler classification scheme.

Range of Brightness	Degree of Concerntration	Cluster Population
(a)	(b)	(c)
1 - Majority of stellar objects show similar brightness.	I - Strong central concentration (Detached)	p - Poor ($n < 50$)
2 - Moderate brightness ranges between stellar objects.	II - Little central concentration (Detached)	m - Medium ($50 < n < 100$)
3 - Both bright and feint stellar objects	III - No disenable concentration	r - Rich ($n > 100$)
	IV - Clusters not well detached (Strong field concentration)	

Note—Where n denotes the amounts the stellar population in a given cluster. For example Pleiades is a I3rn cluster and Hyades is a II3m cluster. Where the 'n' flag on a classification relates if the cluster shows nebulosity.

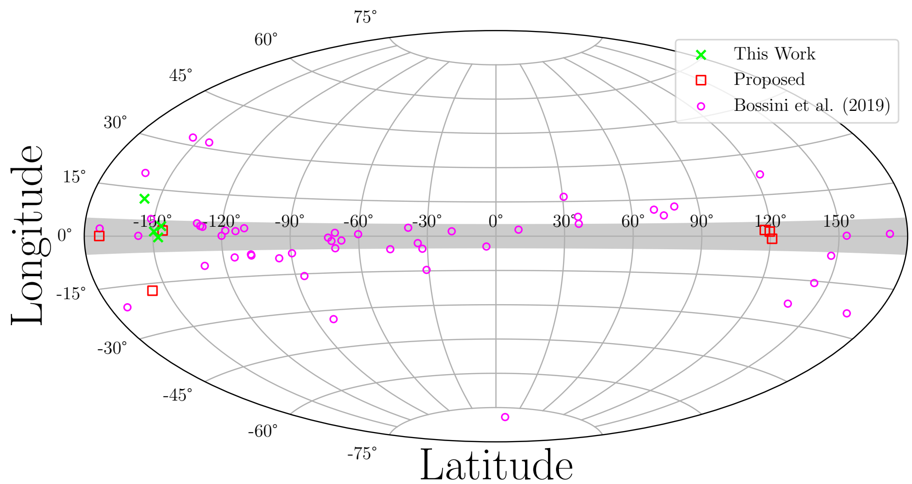

Figure 1. Aitoff projection of targets in terms of galactic co-ordinates, longitude (l) and laititude (b). Targets observed at CAHA are observed in X, the orginal proposal targets shown in X and studies by Bossini et al. (2019) and

3. SUPPLEMENTARY DATA

This study compiles X clusters to aid the observational data. When searching for studies to compliment this work use Gaia's second data release (DR2) was set given preference. The reason for the use of supplementary data was to provide a more varying survey of the galactic disk. The first data set implented was 269 clusters analysed and catalogued by Bossini et al. (2019). This dataset contains large sample of clusters analysed from Gaia DR2, with each of the clusters containg a high degree homogenity amoung the stelllar population. The cluster populations were determined using Bayesian methods of statistics along with DR2 astrometric data. In doing this the probablity of each star being a member of each clusters was approximately X. The parameters of each cluster was found using PARSEC isochrones (Bressan et al. 2012). This data set worked well to fill out a sample size in the galactic disk as seen in fig. 1. Although this survey contained a good amount of clusters with varying age it lacked some the ancient clusters of the milkey way. To supplement this gap the Swift UVOT near-infrared isochrone study using Gaia DR2 (Siegel et al. 2019) was added to the pool of clusters for analysis.

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Table 2. Results of Trumpler classification on observed targets.

Target	ΔV_{mag}	ΔB_{mag}	σ_s	Population n	
(1)	(2)	(3)	(4)	(5)	(6)
Berkeley 28					m
Bochum 2					
NGC2324	12	12	12	333	r
NGC2324					r

Note—Where n denotes the amounts the stellar population in a given cluster. For example Pleiades is a I3rn cluster and Hyades is a II3m cluster. Where the 'n' flag on a classification relates if the cluster shows nebulosity.

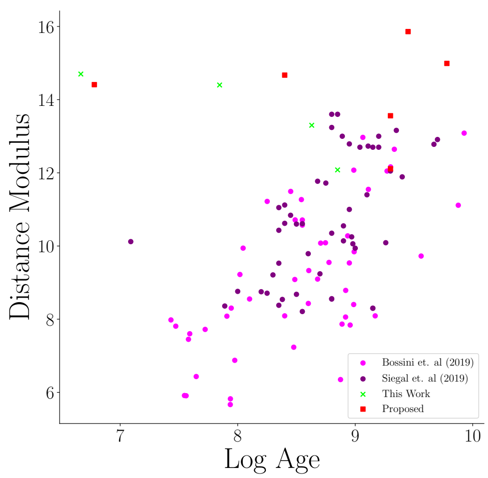

Figure 2. Distance against the log age of both observed targets, proposed targets and supplementary targets.

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ACKNOWLEDGMENTS

I would like to give my thanks to Dr. Antonio Martin Carillo for his patience, warmth and levity throughout this project. He made this project an absolute joy from start to finish. I would like to give a special thanks to Camin Mac Cionna for his marvelous code, coffee and career advice and to my open cluster partner in crime Eoin Fitzpatrick for making my exploration of the universe a little less lonely.
Furthermore, I would like to thank my peers for making the last four years of exploring the universe the best experience I've ever had.
Finally, to my family whose unwavering support and help in the pursuit of my dreams always. Thank you for making all of this possible.

APPENDIX