

Photometric Analysis and Isochrone Fitting of Open Clusters Messier 37 and Messier 41

Tulika Mishra

INTRODUCTION

This study presents a photometric analysis of the open star clusters Messier 37 and Messier 41, utilising:

- Ground-based images obtained from the QMUL Observatory telescope
- Space-based data from the Gaia mission

The primary objective is to determine the ages of these clusters through isochrone fitting techniques. Additionally, the analysis examines the impact of interstellar extinction on isochrones formed and, hence, the determination of the age of star clusters.

OBSERVATION AND COLLECTION

Photometric observations of Messier 37 were conducted at the Queen Mary University of London Astronomical Observatory using a Celestron C14, Schmidt-Cassegrain telescope. Images of the cluster and standard stars were taken through Johnson-Cousins U, B, V, R, and I filters.

For the B and V filters, calibration data was acquired, including:

- 10 dark frames
- 10 bias frames
- 10 flat frames
- 10 light frames per filter

To supplement the ground-based observations and enable a more precise analysis of both Messier 37 and Messier 41, additional astrometric and photometric data was sourced from Gaia Data Release 3 (DR3).

DATA REDUCTION AND STANDARDIZATION

Images in the B and V filters were calibrated using standard reduction techniques, including bias subtraction, flat-field correction, dark frame removal, and image alignment with plate solving.

We then filtered down the data to 106 stars ranging in brightness to collect stars in different stages of star evolution, which were then used for plotting the colour-magnitude diagram. Gaia DR3 data for M37 was filtered using proper motion criteria to supplement this, yielding 1,883 likely cluster members.

A similar method was applied to M41, resulting in a cleaned sample of 1,350 stars.

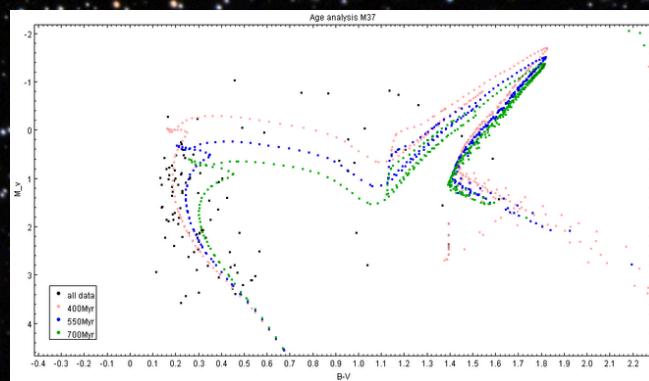


Fig 1: Colour magnitude diagram M37 using QMUL observatory data

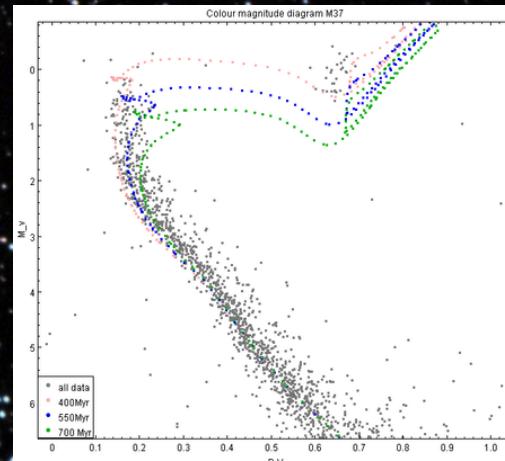


Fig 2: Colour magnitude diagram M37 using Gaia DR3

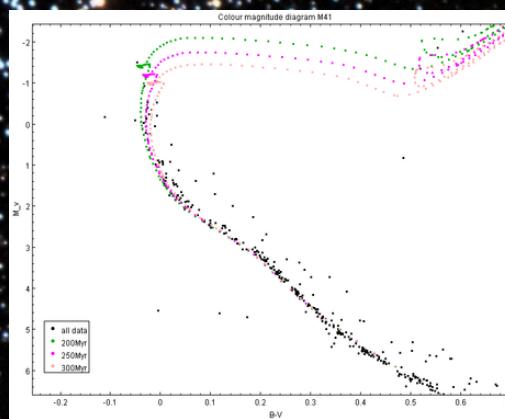


Fig 3: Colour magnitude diagram M41 using Gaia dr3

Results

Star cluster	Total extinction Av (mag)	Metal fraction (assumed)	Age(Myrs)	Distance (pc)
M37	0.7	0.0152	400-500	1400
M41	0.0	0.0152	250-300	705

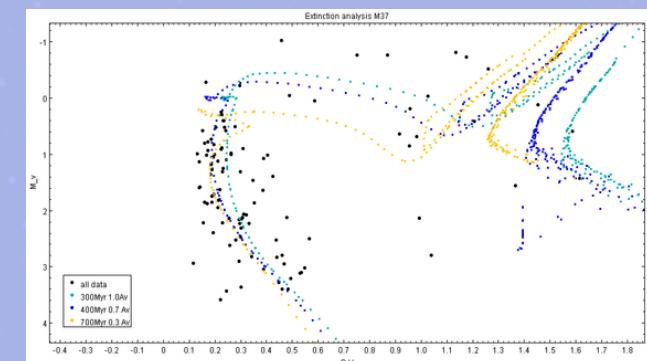
ANALYSIS

- Colour-Magnitude Diagrams (CMDs) were constructed by plotting (B-V) colour indices against the absolute V-band magnitude M_{-V} . Isochrone fitting was performed using PARSEC models, assuming the default metallicity of $Z = 0.0152$.
- Cluster distances were estimated using parallax values from Gaia DR3.

EXTINCTION ANALYSIS

Interstellar extinction, caused by dust between Earth and the star cluster, results in both dimming and reddening of starlight due to absorption and scattering of light due to dust particles.

Extinction values were estimated using a combination of existing literature and trial-and-error adjustments to achieve the best isochrone fit.



CONCLUSION

- For M37, the best-fit age is 550 Myr (range: 300–700 Myr) with an extinction of 0.7 mag. For M41, the best-fit age is 250 Myr (range: 200–300 Myr) with negligible extinction. These results align well with existing literature.
- Differences between CMDs from QMUL and Gaia for M37 likely stem from:
 - Atmospheric distortion
 - Lower photometric precision
 - Crowding due to limited spatial resolution
 - No proper motion filtering in ground-based data

REFERENCES

- Gaia Collaboration et al., 2022, *Astronomy & Astrophysics*, Volume 667, A1
- WIYN Open Cluster Study: Photometry of Star Cluster M41
- "Signature of a chemical spread in the open cluster M37" by M. Griglio et al. (2022)

ACKNOWLEDGMENTS

QMUL Observatory, supervisors