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AST3722C: Observational Techniques

# BVRI Photometry and Isochrone Ages of Two Open Clusters

*NGC 884 (h Persei) and the Orion Nebula Cluster from UF's Campus Teaching Observatory*

**CTO 11″ & 14″**
ZWO ASI294MM Pro
Johnson–Cousins BVRI
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## Abstract

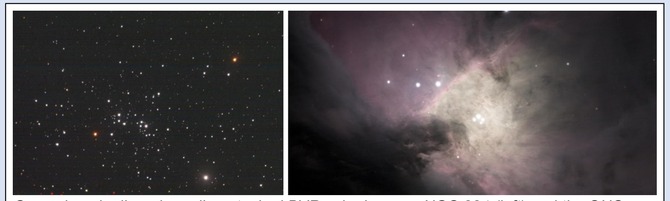
We perform full **BVRI aperture photometry** of two open clusters at very different ages, **NGC 884** (h Persei) and the embedded **Orion Nebula Cluster (ONC)**, from our own observations with the 11″ and 14″ telescopes at UF's Campus Teaching Observatory. A Python pipeline reduces the frames with **per-pixel uncertainty propagation**, detects stars in V, and measures them in all four bands. Calibrating against **Gaia DR3 synthetic Johnson–Cousins photometry** gives zero-point scatter of **0.02–0.04 mag** for NGC 884, and Gaia proper motions and parallaxes select **277 NGC 884 and 38 ONC members**. A $\chi^2$ fit of a fine **PARSEC isochrone** grid with 1,000 bootstrap resamples gives **12.6 Myr for NGC 884**, consistent with the literature 14 Myr, and **~5 Myr (2–6 Myr) for the ONC**. We also measure sky brightness, seeing, read noise, and dark current for both nights.

## Introduction

A **color–magnitude diagram (CMD)** places every star in a cluster by brightness and color. Because cluster stars share one age, distance, and composition, they trace an **isochrone** whose shape is set by age[1].

**NGC 884** (~14 Myr[2]) is old enough that its brightest stars have left the main sequence. The **ONC** (~1–3 Myr[3]) is still embedded in the Orion Molecular Cloud, with many stars still contracting toward it.

**Question:** Can our own BVRI photometry recover the ages of a young and a very young cluster?



*Our reduced, aligned, median-stacked BVR color images: NGC 884 (left) and the ONC (right).*

**NGC 884:** 11″, 2026-02-10, 10 × 10–15 s per filter, airmass 1.22, 0.51″/px

**ONC:** 14″, 2026-01-27, 10 × 7–10 s per filter, airmass 1.22, 0.32″/px

**Measured:** sky 19.6–22.9 mag arcsec$^{-2}$; seeing 3.3–4.0″; read noise 14.8–15.0 e$^-$; dark current ≤ 0.06 e$^-$ px$^{-1}$ s$^{-1}$

## Methodology

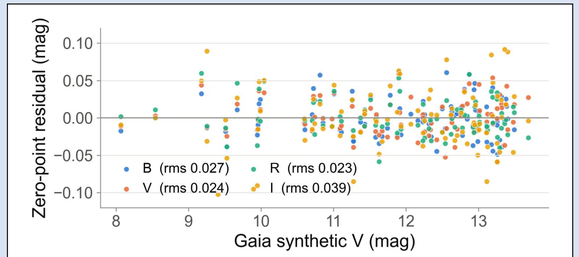
**Reduction:** master bias, dark, and flat frames; frames aligned with astroalign and median-stacked. **Per-pixel σ** is propagated in quadrature through every step.

**Photometry:** DAOStarFinder (6σ) on the V master; forced apertures (r = 1.3 FWHM$_V$) in B, V, R, I, with a smooth 2-D background and annulus sky so the nebula doesn't bias ONC fluxes.

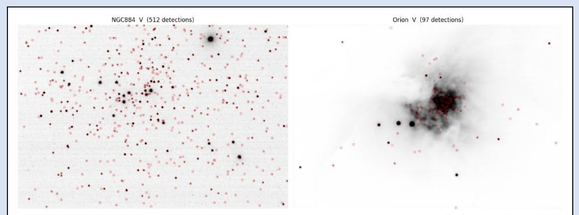
**Calibration:** a TAN-SIP WCS fitted to **Gaia DR3** cross-matches; isolated, unsaturated stars with Gaia synthetic BVRI fit $m_{cat} - m_{inst} = zp + c(B-V)$, 3σ-clipped.

**Membership:** proper-motion and parallax selection; distance from the mean member parallax.

**Ages:** $\chi^2$ over **PARSEC** log(age) 6.0–7.6 in 0.05 dex × E(B−V), with 1,000 bootstrap resamples of the members.

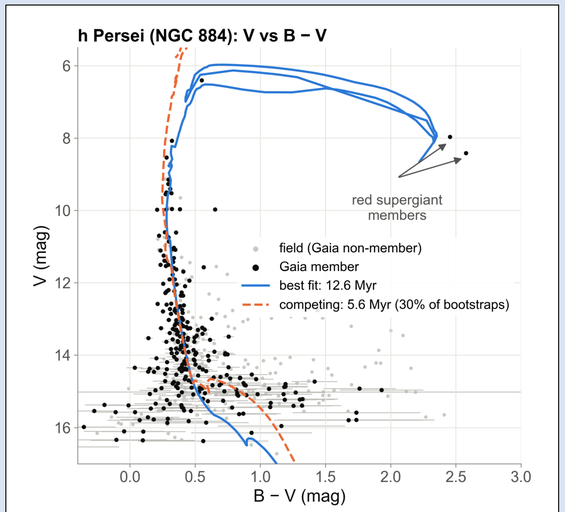



*NGC 884 zero-point residuals against Gaia synthetic V: rms 0.023–0.039 mag with 83–87 calibrators per filter.*

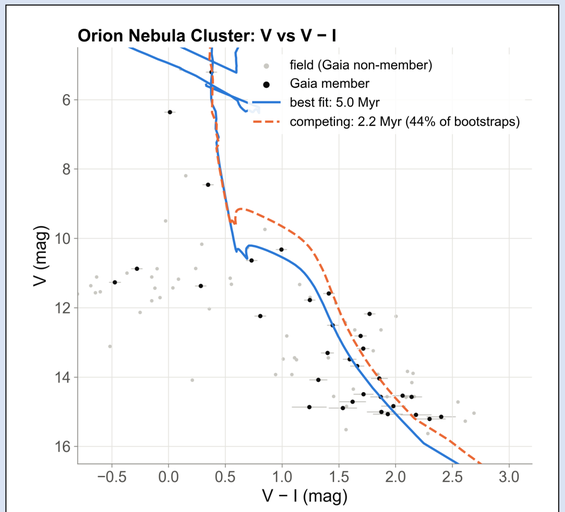



*V-band master frames with DAOStarFinder detections (red): 512 in NGC 884, 97 in the ONC.*

## Results & Discussion




*NGC 884, V vs B−V: 277 Gaia members (black) over field stars (grey). Best fit **12.6 Myr**, E(B−V) = 0.54, distance 2.36 kpc from Gaia parallax. Red supergiant members mark the evolved stars.*



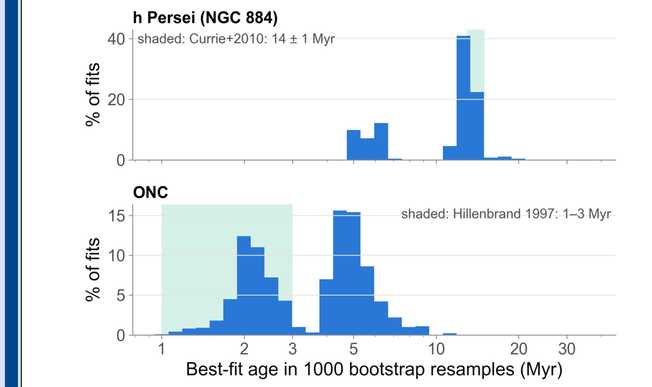

*ONC, V vs V−I: 38 Gaia members. Best fit **5.0 Myr** (blue), with a competing 2.2 Myr solution (dashed) in 44% of bootstraps; distance 392 pc from Gaia parallax.*

**NGC 884: 12.6 Myr** (lit. 14 Myr) **ONC: 5.0 Myr**, 2–6 Myr (lit. 1–3 Myr)

## Conclusion

Calibrating against Gaia DR3 instead of 3–4 hand-picked Tycho-2 stars cuts the zero-point scatter from **0.13–0.5 mag to 0.02–0.04 mag**, and Gaia membership removes the field stars that blurred our first CMDs.

The isochrone fits give **NGC 884 an age of 12.6 Myr**, consistent with the literature. The **ONC fit is bimodal (~2 or ~5 Myr)**: its embedded, reddened, pre-main-sequence stars are hard to fit from the optical alone.




*Best-fit age across 1,000 bootstrap resamples. Shading: literature ages (Currie+2010; Hillenbrand 1997).*

## Future Research

- **Near-IR photometry** to see through the ONC's dust
- **Pre-main-sequence models** for the youngest stars
- **Differential reddening** maps across each field
- **PSF photometry** in the crowded ONC core

## Acknowledgements

Observed with lab partners **Jackson Lyle, Aanya Bhandari, and Sara Grinbaum**. Uses **Gaia DR3** (ESA), APASS, and Tycho-2.

## References

1. Bressan A. et al. 2012, *MNRAS*, 427, 127
2. Currie T. et al. 2010, *ApJS*, 186, 191
3. Hillenbrand L. A. 1997, *AJ*, 113, 1733
4. Gaia Collab., Vallenari A. et al. 2023, *A&A*, 674, A1
5. Gaia Collab., Montegriffo P. et al. 2023, *A&A*, 674, A33
6. Lindegren L. et al. 2021, *A&A*, 649, A4