Astrometric and Photometric Analysis of the Open Star Clusters Berkeley 6 and S1 Using Gaia DR3

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Introduction

- Open star clusters are fundamental "laboratories" for studying stellar evolution, as all members share a common origin and age.
- Gaia DR3 provides high-precision 5D astrometry —position, parallax (distance), and proper motions—for nearly 2 billion stars.
- Density-based clustering identifies true members by isolating stars that move together as a single, coherent unit in space.

Motivation

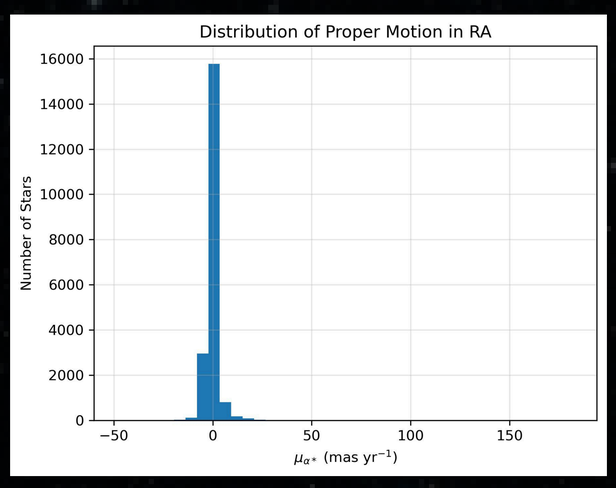
- Berkeley 6 and S1 are identified as "candidate" or "possible" clusters in existing catalogs but lack high-precision verification.
- Located toward the Galactic Anticenter, these targets offer a clear window into the outer disk with significantly lower dust obscuration.
- Modern Gaia analysis is required to differentiate these potentially gravitationally bound systems from random chance stellar alignments.

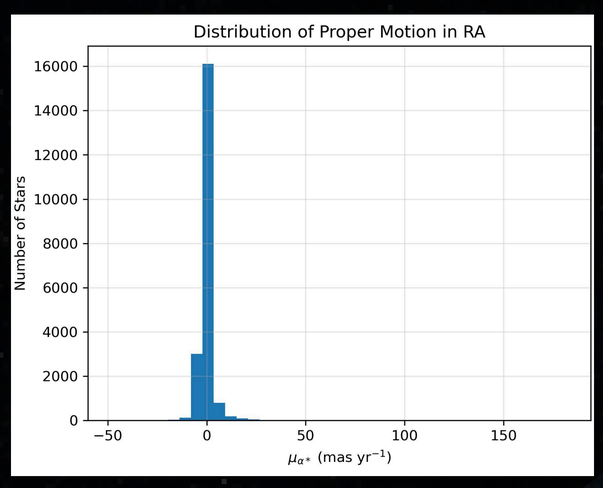
Methodology

- .Proper motion histograms and strict RUWE–magnitude cuts remove spurious data and highlight density peaks.
- 5D Parameters: RA, Dec, Parallax, μ_a*, $\mu\delta$ — scaled to form a balanced parameter space.
- HDBSCAN detects dense cluster cores automatically.
- The VPD confirms a tight kinematic grouping, and stars with membership probability ≥ 0.8 are validated through CMD analysis.

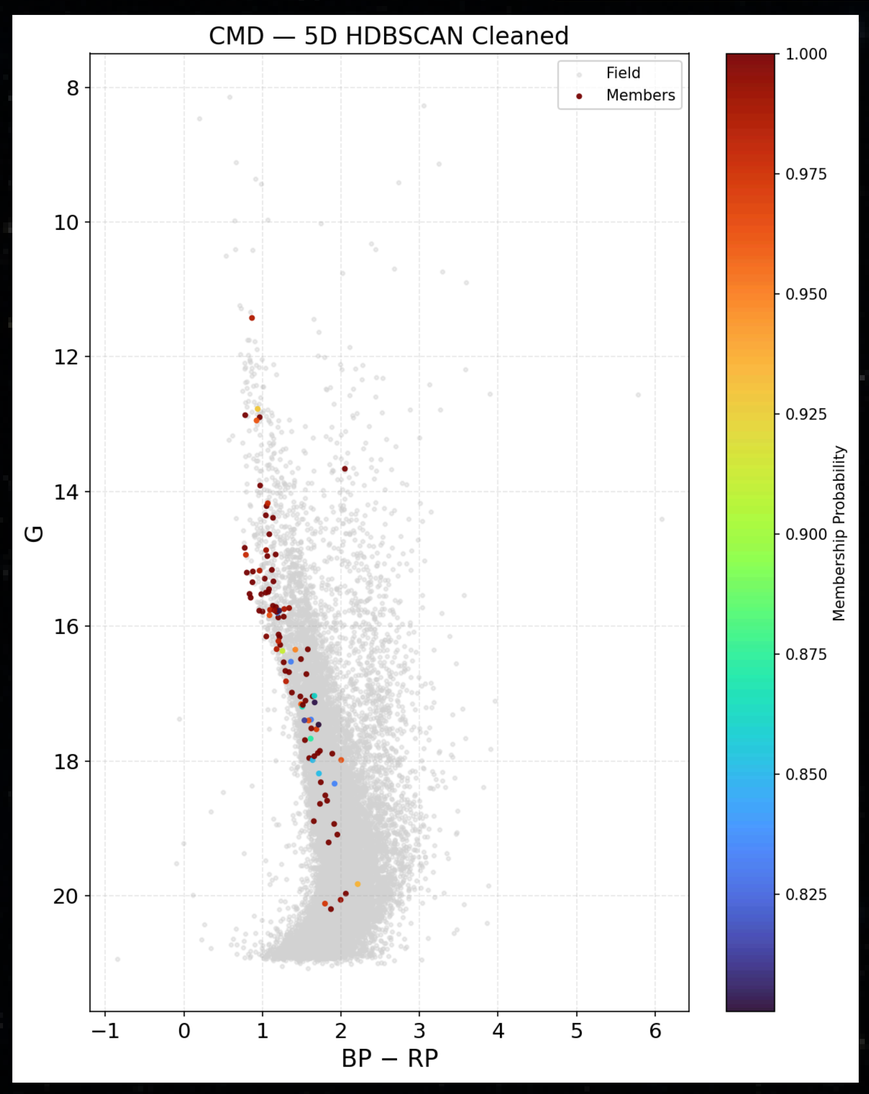
Histogram of Proper Motion in RA for Both Clusters

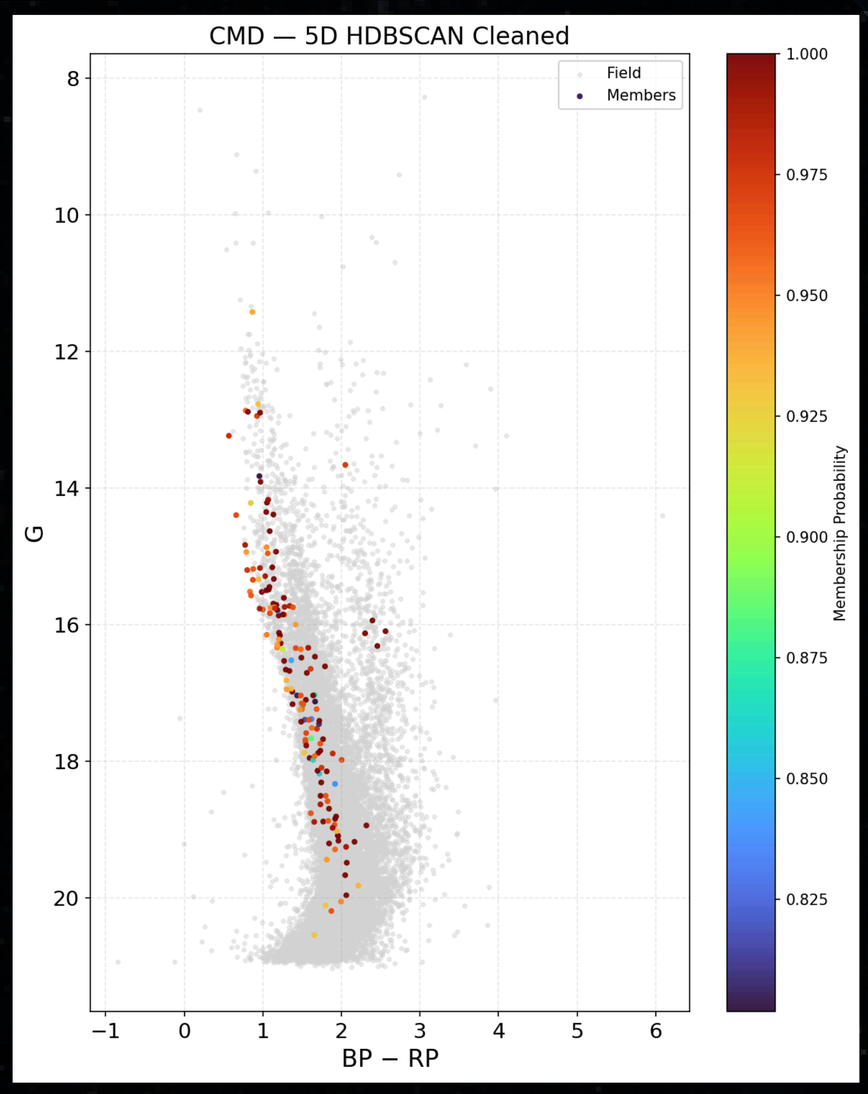
- The histogram shows the distribution of stellar proper motion in right ascension (μ_a*).
- A strong central peak is visible, indicating a concentration of stars sharing similar motion — likely cluster members.
- The broader spread around the peak represents field star contamination.
- This distribution helps in distinguishing cluster members from background stars based on kinematics.





Color–Magnitude Diagram





- 5D HDBSCAN significantly reduces field contamination, revealing a clearer and tighter main sequence.
- High-probability members trace the cluster sequence distinctly, improving membership reliability.

HDBSCAN Results

Berkeley 6 (Be 6):

Noise: 19088 | Cluster 0: 203 | Cluster 1: 44

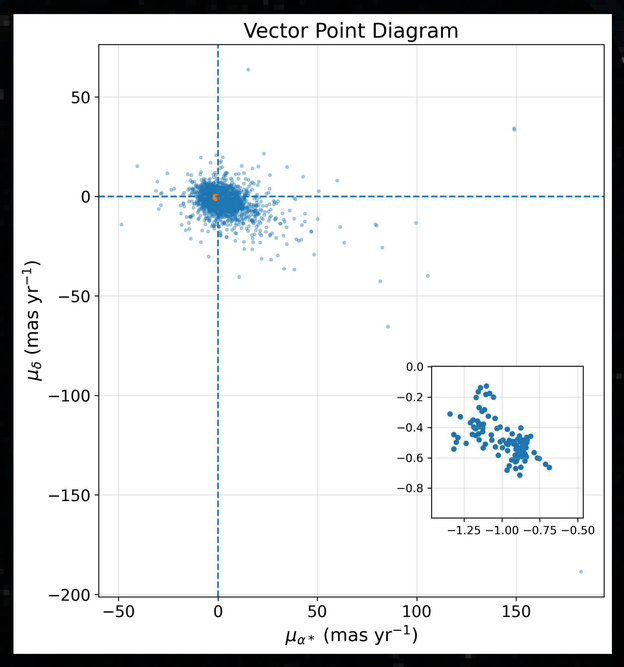
S1:

Noise: 19421 | Cluster 0: 203 | Cluster 1: 99

Both regions show two compact groups embedded in dominant field noise.

Be 6 and S1 are separated by ~3 arcminutes on the sky.

Vector point Diagram



- The VPD shows proper motion in RA (μ_a*) versus Dec ($\mu\delta$).
- Cluster members form a compact concentration, while field stars are more widely scattered.
- The inset highlights the tight kinematic grouping around the cluster's median proper motion, confirming reliable member selection

References and Acknowledgment

References

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- Koç & Yontan (2023), BEUJS, 12(2), 369 — Parameters of Berkeley 6.
- Gaia Collaboration (2022), A&A — Gaia Data Release 3.
- McInnes et al. (2017), JOSS, 2, 205 — HDBSCAN clustering method.

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