Massive Stars Across Redshifts in the Era of JWST and Large Surveys
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Yellow Hypergiants and Where to Find Them

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Abstract. Yellow Hypergiants and Yellow Supergiants represent short transitional stages in the evolution of massive stars. Their lifetimes are shorter than the typical dissolution times of stellar clusters and associations. We investigated the group memberships of 35 luminous Galactic Yellow Super- and Hypergiants using Gaia DR3. We improved the distance estimates for 26 targets based on stars with reliable astrometry projected close to each target. Most known Yellow Hypergiants can be found in loosely bound associations or have no clear group membership.

Keywords. Stars: distances, supergiants, open clusters, associations

1. Introduction

Yellow Hypergiants (YHGs) and Yellow Supergiants (YSGs) occupy the upper region of the Hertzsprung-Russell diagram. Their main differentiating factor is their evolutionary status: YHGs are evolved stars that have lost much of their mass during the Red Supergiant (RSG) phase and are now evolving back towards higher temperatures (de Jager *et al.* 1998), while YSGs are less evolved and have yet to become RSGs. However, finding alignment of these objects with stellar evolutionary tracks is hampered by their uncertain distance determinations.

Many evolved massive stars are found in young stellar clusters, but estimates of the fraction born in bound clusters range from about 10% (Grudić *et al.* 2023) up to 80% (Quintana *et al.* 2025). If a cluster survives the initial gas expulsion, its dissolution time depends on its initial mass. For example, a small cluster with an initial mass of $100 M_{\odot}$ remains bound for about $\log t_{\rm dis} = 7.89$ years, and the time increases for more massive clusters (Lamers & Gieles 2006). Other young massive stars are found in loosely bound OB associations, with approximate ages of $\log(\mathrm{Age}) \approx 6.7 - 7.0$ (5-10 Myr) based on their member spectral types (Melnik & Dambis 2020). Single-star evolution models predict that only stars with $M_{\rm ini} > 20 M_{\odot}$ evolve into YHGs, with lifetimes of $\log(\mathrm{Age}) \approx 7.0$ (Ekström *et al.* 2012). Therefore, unless ejected, YHGs and YSGs are likely still located near their birth environments. Using Gaia DR3, we revisit the cluster and association memberships of Galactic YSGs and YHGs, explore links to their evolutionary states, and improve distances for stars with uncertain parallaxes.

2. Methods

We selected 35 luminous Galactic YSGs and YHGs. We used astrometric data from Gaia DR3 (Gaia Collaboration *et al.* 2023) and catalogues of stellar clusters (Hunt & Reffert 2024) and associations (Chemel *et al.* 2022) to compare the kinematics of

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Table 1. Identified cluster and association memberships of YHGs and YSGs.

Object	Type	Group type	Group name	log(Age)	Group ref.
HD 10494	YSG	cluster	NGC 654	7.28	[1]
ϕ Cas	YSG	cluster	NGC 457	7.35	[1]
HD 18391	YSG	cluster	SAI 25	7.27	[1]
R Pup	YHG	cluster	NGC 2439	7.76	[1]
TYC 8958-479-1	YSG	cluster	Barbá 2	7	[2]
CD-59 5594	YSG	cluster	Pismis 21	6.94	[1]
V915 Sco	YSG	cluster	HSC 2870	6.89	[1]
[FMR2006] 15	YHG	cluster	RSGC 1	6.85-7.08	[3]
V1452 Aql	YSG	cluster	CWNU 1591	7.1	[4]
HD 331777	YSG	cluster	Kronberger 54	7.03	[1]
RW Cep	YHG?	cluster	Berkeley 94	7.08	[1]
V810 Cen	YSG	cluster?	Stock 14	7.17	[1]
V870 Sco	YSG	cluster?	NGC 6231	6.64	[1]
ϵ Aur	YSG	assoc.	No. 147		[5]
HD 57118	YSG	assoc.	No. 25		[5]
HD 74180	YSG	assoc.	No. 107		[5]
HD 75276	YSG	assoc.	No. 106		[5]
HD 96918	YHG	assoc.	No. 210/211		[5]
V925 Sco	YSG	assoc.	No. 82		[5]
V1027 Cyg	YSG	assoc.	No. 15		[5]
V509 Cas	YHG	assoc.	No. 120		[5]
6 Cas	YHG	assoc.	No. 141		[5]
HD 223777	YSG	assoc	No. 141		[5]
UCAC2 4867478	YSG	group			
IRAS 18357-0604	YHG?	group			[6]
V709 Car	YSG?	group			
HR 5171A	YHG	SFR?	Gum 48d		[7]
IRAS 17163-3907	YHG	SFR?	RCW 121/122		[8]
IRC +10420	YHG	non-member			
IRAS 14394-6059	YSG	non-member			
HD 179821	YHG	non-member			
ρ Cas	YHG	non-member			
o^1 Cen	YSG	non-member			
HD 12399	YSG	non-member			
HD 144812	YHG?	non-member			

Notes: [1] Hunt & Reffert (2024), [2] Maíz Apellániz & Negueruela (2025), [3] Figer *et al.* (2006), [4] He *et al.* (2023), [5] Chemel *et al.* (2022), [6] Clark *et al.* (2014), [7] Chesneau *et al.* (2014), [8] Wallström *et al.* (2015). Cluster ages have errors ∼0.2 dex.

each target with stars within a 1-degree sky region. We determined cluster memberships based on:

- Projected on-sky location
- Similarity in proper motion: 3σ tolerance
- Parallax: only if reliable, $\varpi/\sigma_{\varpi} > 5$

We combined parallaxes of nearby stars following Campillay *et al.* (2019) and estimated group distances using Bayesian inference with priors from Bailer-Jones *et al.* (2021).

3. Results

Group memberships of the sample stars are listed in Table 1. Most of the 13 stars identified as cluster members are YSGs, in clusters aged around 10 Myr. Two stars – V810 Cen and V870 Sco – are projected on a cluster on-sky, but their proper motions are inconsistent with being cluster members and they may be background stars. Three YHGs are located in cluster environments: R Pup in the oldest cluster (though the listed age may be too high for co-formation); [FMR 2006] 15 in a rare RSG cluster (Figer *et al.* 2006); and RW Cep is a Red/Yellow Hypergiant in a young cluster.

Three YHGs and seven YSGs have proper motions compatible with OB associations in Chemel *et al.* (2022). Some stars may belong to association-like stellar groups.

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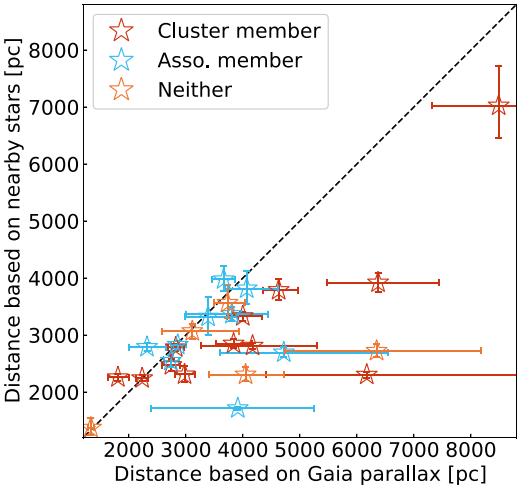


Figure 1. Comparison between distances from parallaxes (Bailer-Jones *et al.* 2021) and based on identified stellar groups (our work). The dashed line is 1:1 relation.

IRAS 18357-0604 likely belongs to an association rich in RSGs (Clark *et al.* 2014). UCAC2 4867478 and V709 Car have groups of stars within a 10′ projected radius with similar proper motions and distances, but no matching clusters are listed in used catalogues.

Two YHGs – HR 5171A and IRAS 17163-3907 – may belong to star-forming regions (SFR), but their distances are highly uncertain. Gaia DR3 data for possible nearby reddened and distant stars have large uncertainties, and we were not able to confirm or exclude membership.

Finally, non-membership does not necessarily mean that the star is isolated. For the most distant objects, e.g. IRC +10420 and HD 179821 nearby Main Sequence stars may be too faint. Alternatively, if the star has been dynamically ejected, its proper motion no longer aligns with its birth group.

Using nearby stars with good quality parallaxes ($\varpi/\sigma_\varpi > 5$), we calculated the mean group distances. Our results agree well with Bailer-Jones *et al.* (2021) for stars with reliable parallaxes (see Fig. 1). For stars with large parallax errors, Gaia distances tend to be significantly larger.

4. Conclusions

- 10 of 13 YHGs and YHG candidates are located in loosely bound stellar environments such as associations or are not clearly affiliated to a stellar population.
- YSGs are equally common in clusters and associations.
- We improved the distance estimates for 26 of 35 stars. For six, the new distances are smaller by more than 1000 pc compared to Bailer-Jones *et al.* (2021).

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