Distance estimation of young eruptive stars using star clusters

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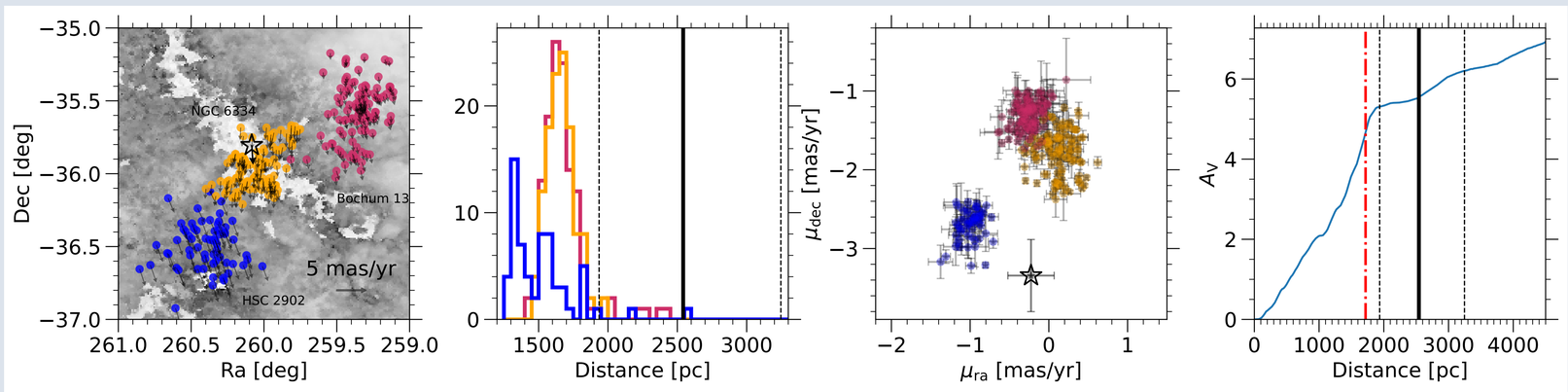
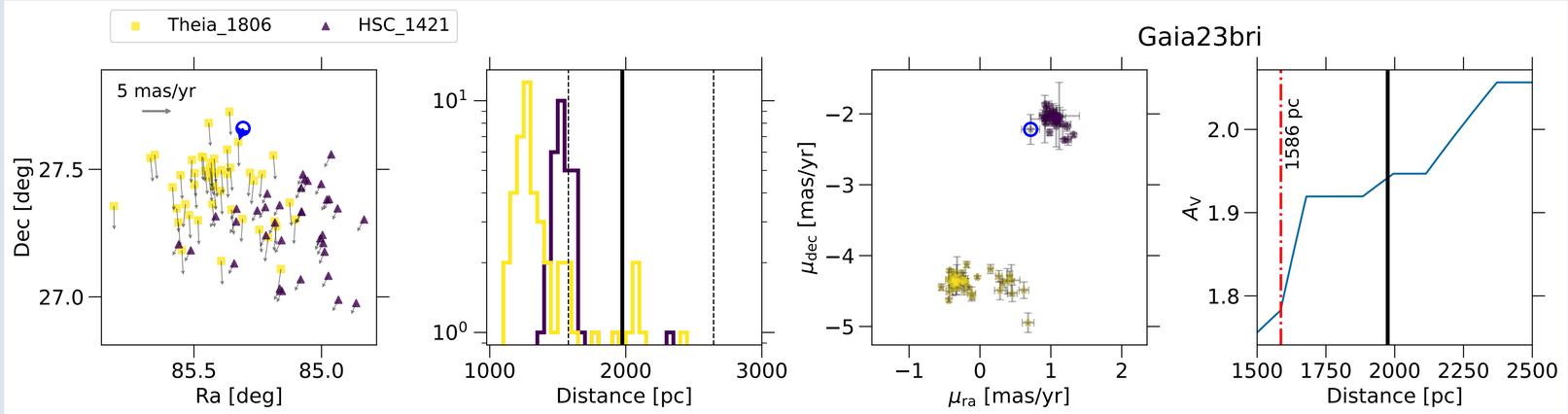
Introduction

To determine the basic properties of young stars, such as their accretion rates, reliable distance estimates are required. Thanks to the Gaia spacecraft, astrometric information is now available for more than 1 billion stars. However, many observed young eruptive stars are faint, and their astrometric measurements therefore carry large uncertainties. Since stars form in clusters and young stars are expected to remain close to their natal environments, cluster membership can be used to constrain their distances. In this poster, I present several case studies from our recent work demonstrating how more precise distances to YSOs can be obtained using star clusters and extinction maps.

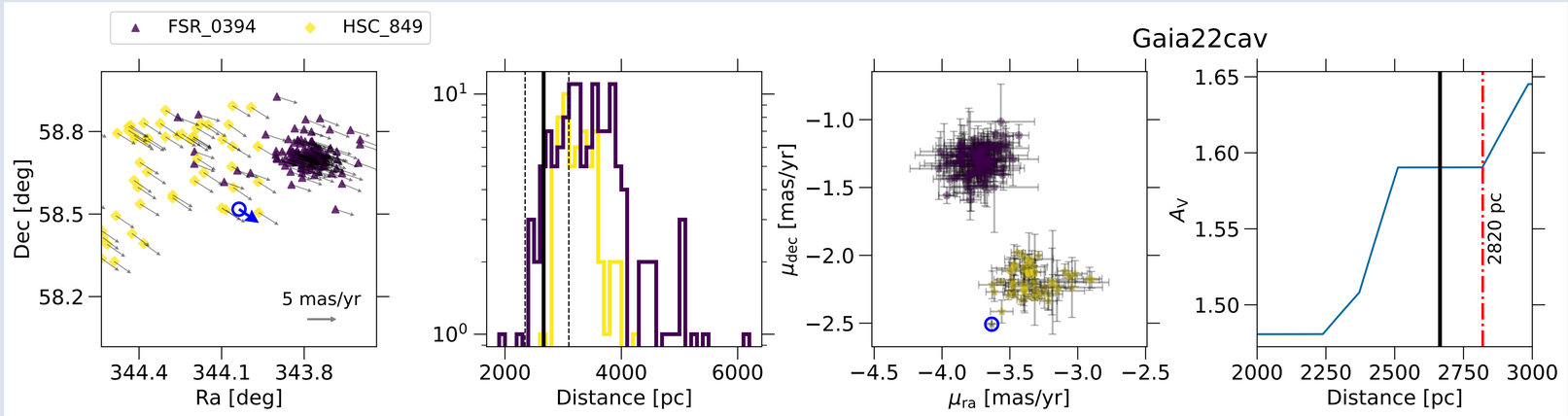
Examples



Gaia20dsk (Németh et al. 2026)



Gaia23bri (Giannini et al. 2026)

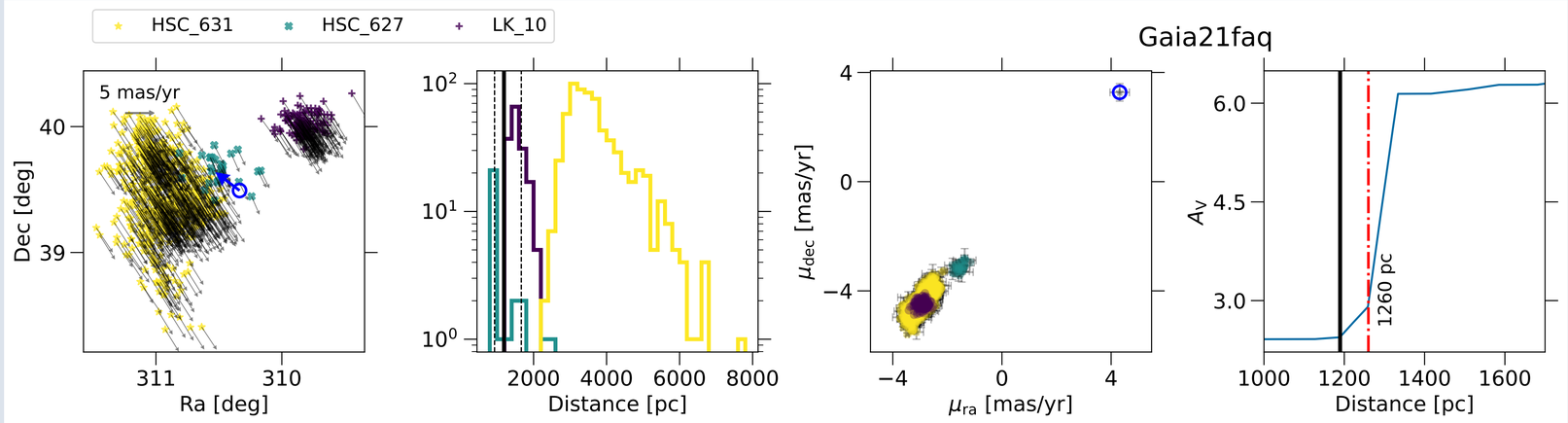


Gaia22cav (Nagy et al., in prep.)

Limitations

Although this method is effective for deriving more precise distances, it also has several limitations and, in some cases, cannot be applied:

- if the target source is not included in the Gaia database
- if the target has distance measurements but lacks proper motion information
- if no observed clusters are located in the vicinity of the target
- if nearby clusters are not co-moving with the target



(Giannini et al. 2026)

Gaia distances

Although ∼1.46 billion sources have full astrometric solutions in Gaia DR3, many faint objects have large parallax uncertainties, precluding simple parallax inversion. Bailer-Jones et al. (2021) adopted a probabilistic approach by constructing priors based on a three-dimensional model of the Milky Way. They provide two distance estimates: the "geometric" distance, which relies primarily on parallax information, and the "photogeometric" distance, which additionally incorporates colours and apparent magnitudes into the prior. Unfortunately, these distance estimates often carry large uncertainties.

Cluster catalogue

For this work, we used the catalogue of Hunt & Reffert (2023), currently the largest catalogue of stellar clusters based on Gaia DR3 data. It contains 7167 open and globular clusters comprising more than 1.2 million stars. The catalogue provides basic cluster properties, including mean coordinates, parallaxes/distances, proper motions, and ages. An extended version by Hunt & Reffert (2024) additionally includes Jacobi radii and cluster mass estimates.

Extinction

A sudden increase in cumulative extinction as a function of distance is a characteristic signature of star-forming regions. Three-dimensional extinction maps can therefore also be used to estimate the distances of young stars. The maps used in this work are:

- Edenhofer et al. (2024): a dust map with ∼pc-scale resolution extending to 1.25 kpc
- Bayestar19 (Green et al. 2019): a dust map based on Gaia DR2, Pan-STARRS, and 2MASS data. The map covers the sky above Dec = −30°
- DECaPS (Zucker et al. 2025): based on VVV, 2MASS, unWISE, and Gaia DR3 data; complementary to Bayestar19

Acknowledgement

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