STAR MEMBERSHIP IN THREE NEARBY OPEN CLUSTERS

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We carry out a star membership study in three nearby open clusters: Pleiades, Praesepe and Blanco 1, employing a Bayesian astrometric model with proper motions and an unsupervised clustering machine learning algorithm DBSCAN using positions, proper motions and parallaxes, all data from the Gaia Data Release 3 catalogue. The final membership lists are the crossmatch between results from both methods.

The Bayesian model uses two bivariate probability density functions: a circular for the open cluster $\psi_c(\mu_{\alpha*,i}, \mu_{\delta,i})$ and an elliptical for the field stars $\psi_f(\mu_{\alpha*,i}, \mu_{\delta,i})$ (Vasilevskis et al. 1958). These two densities can be collected in the joint probability function given by Eq. (1), which depends on nine parameters that were estimated via the maximum likelihood estimation and Markov chain Monte Carlo. We maximize the likelihood function given by Eq. (2), then, membership probabilities were computed using the Eq. (3).

$$\psi(\mu_{\alpha*,i}, \mu_{\delta,i}) = n_c\psi_c(\mu_{\alpha*,i}, \mu_{\delta,i}) + (1-n_c)\psi_f(\mu_{\alpha*,i}, \mu_{\delta,i}). \quad (1)$$

$$\ln \mathcal{L}(\vec{\theta}) = \sum_{i=1}^{n} \ln \psi(\mu_{\alpha*,i}, \mu_{\delta,i}|\vec{\theta}). \quad (2)$$

$$P_i(cluster|\mu_{\alpha*,i}, \mu_{\delta,i}) = \frac{n_c\psi_c(\mu_{\alpha*,i}, \mu_{\delta,i})}{n_c\psi_c(\mu_{\alpha*,i}, \mu_{\delta,i}) + (1-n_c)\psi_f(\mu_{\alpha*,i}, \mu_{\delta,i})}. \quad (3)$$

The DBSCAN algorithm (Ester et al. 1996) was applied in a five-dimensional astrometric space (α, δ, $\mu_{\alpha*}$, μ_δ, ϖ) computing distances using the Euclidean metric. We standardised data and in order to obtain the ϵ and $minPts$ with the best efficiency, first, we compute the k-th nearest-neighbour distance (k-NND) histogram of data and store the median value as ϵ_{kNN}. Second, generate random samples for data from a Gaussian kernel, compute the k-NND histogram and store the median as ϵ_{rand*}. An average of 30 repetitions was performed and ϵ_{rand} is the average of ϵ_{rand*}. Finally, the ϵ was determined as $\epsilon = (\epsilon_{kNN} + \epsilon_{rand})/2$ (see Fig. 1). We chose $minPts = 8$ for each cluster.

From the selected members, we fit the King model (King 1962) to the radial density profiles in order to compute core and tidal radius (Alfonso & García-Varela. 2023). We also estimate age and metallicity from *Gaia* photometry using BASE-9 (von Hippel et al. 2006) and the PARSEC models (Bressan et al. 2012). These results were close to previous works, however, there are some differences for the tidal radius that may be a product of stretching in the spatial distributions because of coordinate transformations.

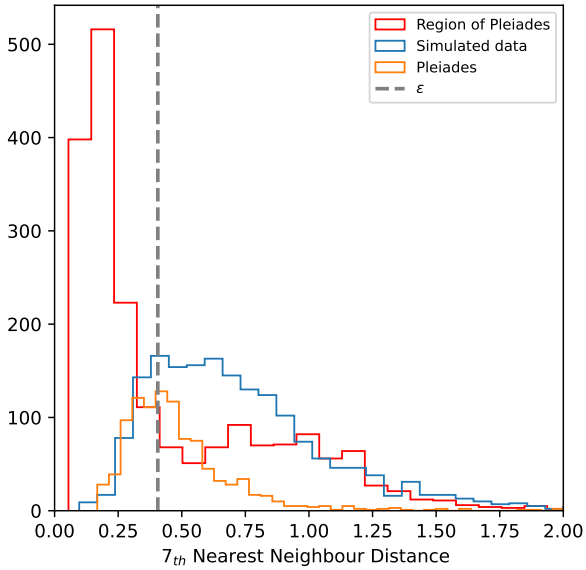

Fig. 1. Histogram of the 7_{th}-NND for the region of Pleiades (red), simulated data (blue), and the Pleiades members selected from the PM model (orange). The grey dashed vertical line is the selected ϵ.

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