Clustering properties of Herbig Ae/Be stars

Alice Pérez Blanco[(1,2)*], René Oudmaijer[(1)], Ricardo Pérez-Martinez[(2)] and Deborah Baines[(3)]
[(1)] University of Leeds (Leeds - UK); [(2)] ISDEFE (ESAC, Madrid - Spain) ; [(3)] QUASAR (ESAC, Madrid - Spain)
*pyagyp@leeds.ac.uk

Abstract We are investigating the presence of clusters around previously known and newly discovered intermediate-mass pre-main sequence HAeBe stars with the detailed astrometric data offered by Gaia. This will enable us to determine the position of the HAeBe stars in the HR diagram and allow us to detect and confirm the presence of the clusters around them. Here, we outline the preliminary results obtained with Gaia DR2 through our code CEREAL.

1 Do HAeBe stars form in clusters?

Testi et al. (1999) analyzed the occurrence of young stellar clusters around HAeBe stars from near-infrared images. They study 44 fields around stars with spectral types from A7 to O9, where rich clusters appear only around stars earlier than B5-B7. We took their targets and another sample from *Vioque et al. 2018* for which we performed a similar analysis with the Gaia DR2 data through the ***ClustER detEction ALgorithm***, CEREAL, which we developed for the detection and analysis of the clusters of the HAeBe stars.

2 ClustER detEction ALgorithm

CEREAL was developed to assess whether a HAeBe star is associated with a cluster or not. This code can detect a cluster given the known value of the star's astrometric parameters. For example, we took Gaia DR2 data in a circular area with a radius ~0.2 degree centred around the HAeBe star: *V590Mon* (Figure 1A), and found a significant number of low mass stars which share similar astrometric parameters with this HAeBe star (Figure 1B).

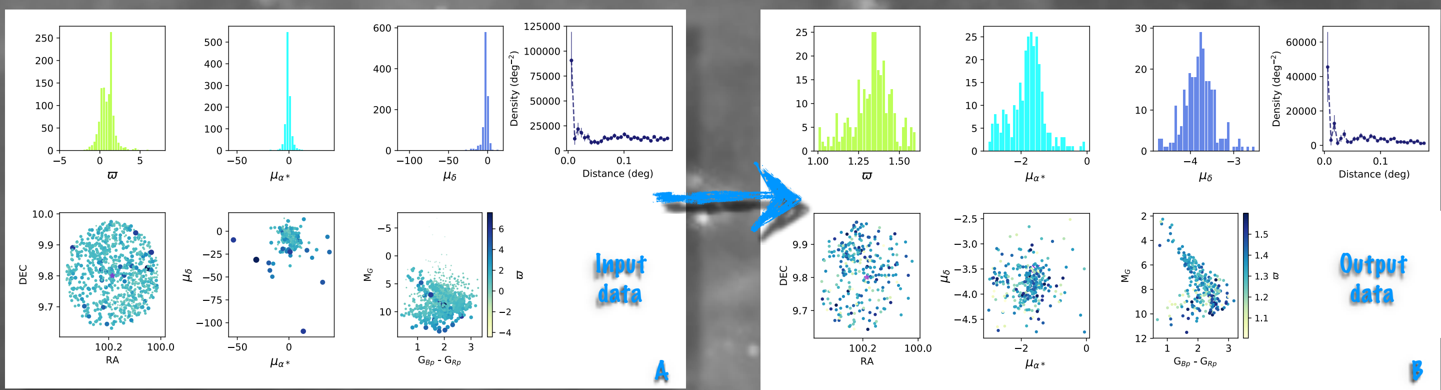

Figure1. CEREAL selection process for the HAeBe stars *V590Mon*. The first three panels on the top display the histograms for the astrometric parameters. Also shown in the top the radio density distribution. The bottom panels represent the Spatial distribution, Proper Motion distribution and the Colour-Magnitude diagram, all of those with a colour bar which reflect the parallax values. Figure A shows the input data from Gaia DR2 and Figure B shows the final selection made by CEREAL.

3

Thanks to the diversity of Gaia DR2 data, we can represent the CEREAL results in several ways. Figure 2 shows the final result obtained with CEREAL for two HAeBe stars (green stars) which are surrounded by a group of stars which share similar properties (Table 1).

Table 1. Astrometric parameters from Gaia DR2

Stars/Parameter	Parallax (mas)	Pmra (mas/yr)	Pmdec (mas/yr)
V361 Cep	1.11±0.02	-1.90±0.04	-3.75±0.04
BD+30 549	3.38±0.08	6.82±0.10	-9.44±0.07

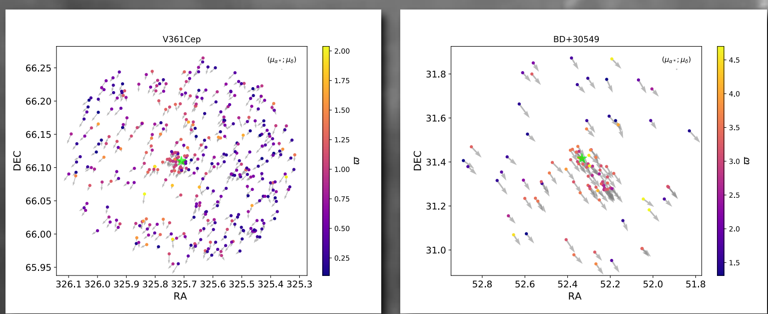

Figure 2. Final result from CEREAL for the HAeBe stars with Gaia DR2. The colour bar represent the parallax and the arrows the proper motions of the sample.

4 CEREAL vs Testi et al.

Comparing the presence of clusters around HAeBe stars, we took the sample of 44 stars from *Testi et al. 1999* and analysed the 43 stars we have in common using CEREAL. As a preliminary results, on the presence of clusters around the B,A type, we found that 52±10% of B type stars and 32±10% of A type stars are likely to be in a clusters and they found that 50±10% of B type star are likely to be in a cluster and none A type star in a cluster. Further analysis will need to be done to understand these differences.

Summary

We have analysed a sample of approximately 200 HAeBe stars with CEREAL using Gaia DR2 to increase the number of objects studied by *Testi et al. (1999)*. So far, we have found ~70 clusters which represent the current sample to obtain the clustering properties for those HAeBe stars. Also, we plan to analyse our sample with clustering algorithms from the literature, like *DBSCAN* and *OPTICS* to compare the number of clusters found by CEREAL.

Acknowledgements
This project has received funding from the European Union's Horizon 2020 research and innovation programme under MSCA ITN-EID grant agreement No 676036.