HArchiBe: An online archive to understand disk evolution around Herbig Ae/Be stars

http://svo2.cab.inta-csic.es/projects/harchibe/

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Background

Protoplanetary disks around Herbig Ae/Be (HAeBes) stars are excellent laboratories to understand how planetary systems form. However, how they evolve is a current issue that is not well understood. On the one hand, Meeus et al. (2001, A&A, 365, 476) classified a small sample of HAeBes in two groups according to the shape of their Spectral Energy Distributions (SEDs) in the Infrared range: Flared *(Group* I*)* and flat *(Group* II*)* disks. An evolution from *Group* I towards *Group* II was suggested due to evidences of grain growth and dust settling towards the midplane (Acke et al. 2004, A&A, 422, 621). On the other hand, direct images with high spatial resolution techniques have revealed gaps in most Meeus G*roup* I HAeBes, but not in the *Group* II, allowing us to hypothesize about other kinds of evolutionary scenarios.

In analogy with the SED classification for lower-mass T Tauri stars, Mendigutía et al. (2012, A&A, 543, A59) classified the SEDs of HAeBes using a different scheme based on the wavelength where the Infrared excess starts: *Group* JH, if the shortest wavelength where the IR excess is detected corresponds to the *J* or *H* band, and *Group* Ks when the IR excess starts at λ ≥ 2.16 μm.

The online archive

An online archive of HAeBe stars (HArchiBe) is currently in development. HArchiBe is a Virtual Observatory compliant archive built in the framework of the Spanish VO using the *SVOCat*[4] publishing tool. This is composed of a sample of 257 stars, which were compiled from Chen et al. (2016, NewA, 44, 1, and references therein) and Carmona et al. (2010, A&A, 517A, 67) (see also Vioque et al. 2018, A&A, 620A, 128). HArchiBe will provide:

1) Distances updated by Gaia DR2 and optical photometry.
2) Stellar parameters, such as temperatures, masses, and ages derived homogeneously from the *VOSA*[5] tool (Bayo et al. 2008, A&A, 492, 277).
3) Mass accretion rates , which have been derived following the same procedure in Arun et al. (2019, AJ, 157, 159).
4) Disks masses for those HAeBes that have available mm and sub-mm fluxes, and from mass accretion rates and ages for all sources.
5) SED classification: Meeus and *JH-Ks* groups.

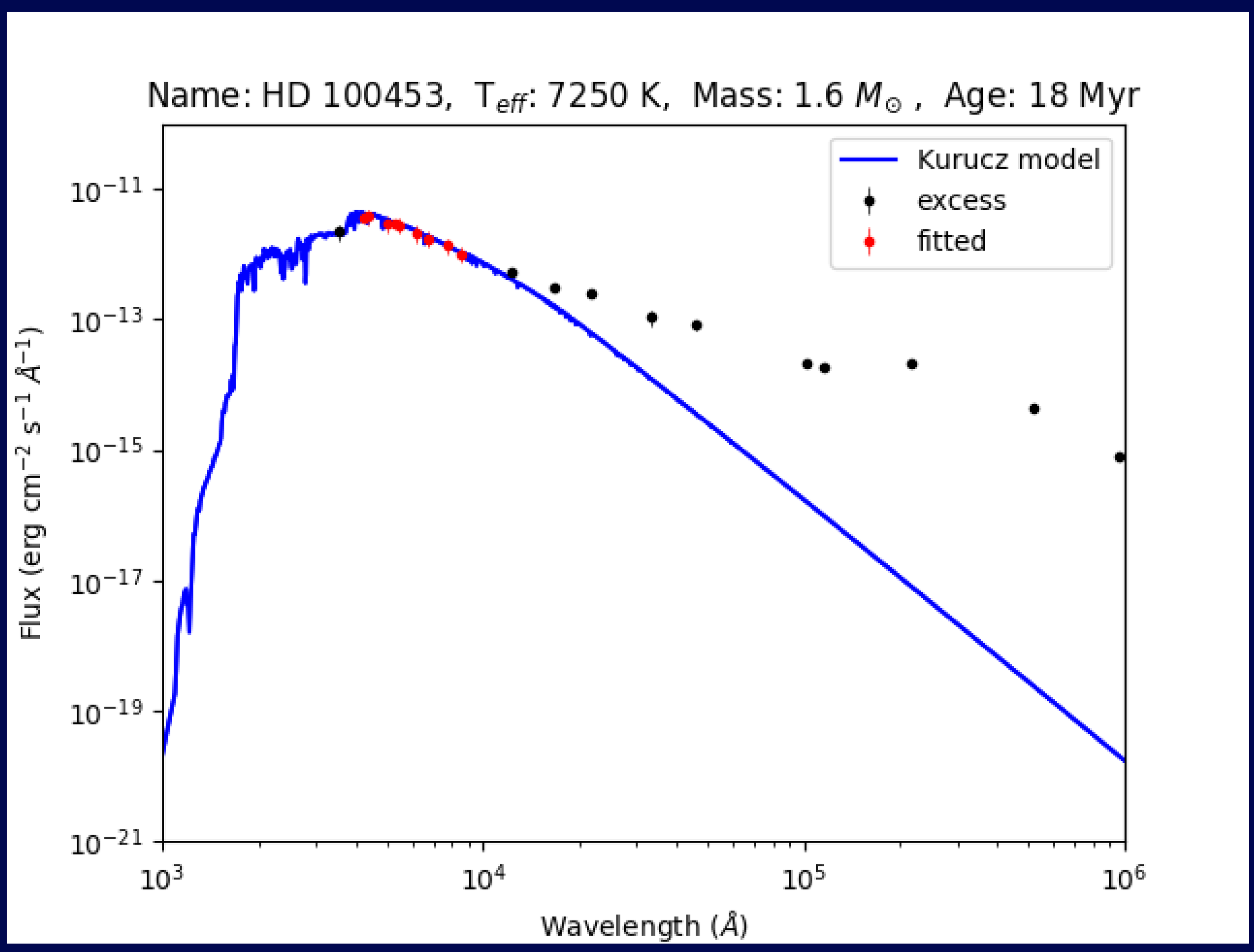

Figure 1: An example of SED fit. The photometry was compiled from the available catalogues in *VOSA* and Fairlamb et al. (2015). The solid blue line corresponds to the theoretical model. Black dots clearly show the UV/IR excess and they have not been considered in the fit. Red dots are the observed photometry, corrected for reddening, that has been fitted by the model.

Consistency and representativeness

A main strength of our study is the homogeneous procedure that has been followed to derive the stellar and disk parameters for a large number of HAeBes stars. Parameters such as the effective temperatures are in good agreement with those ones which have been derived from spectra (Fairlamb et al 2015, MNRAS, 453, 976). Furthermore, **Figure 2** shows that the Initial Mass Function fits the observed sample of HAeBes (without taking into account the first and last bins), indicating that this is a representative sample of the intermediate-mass young stellar-population of the Galaxy.

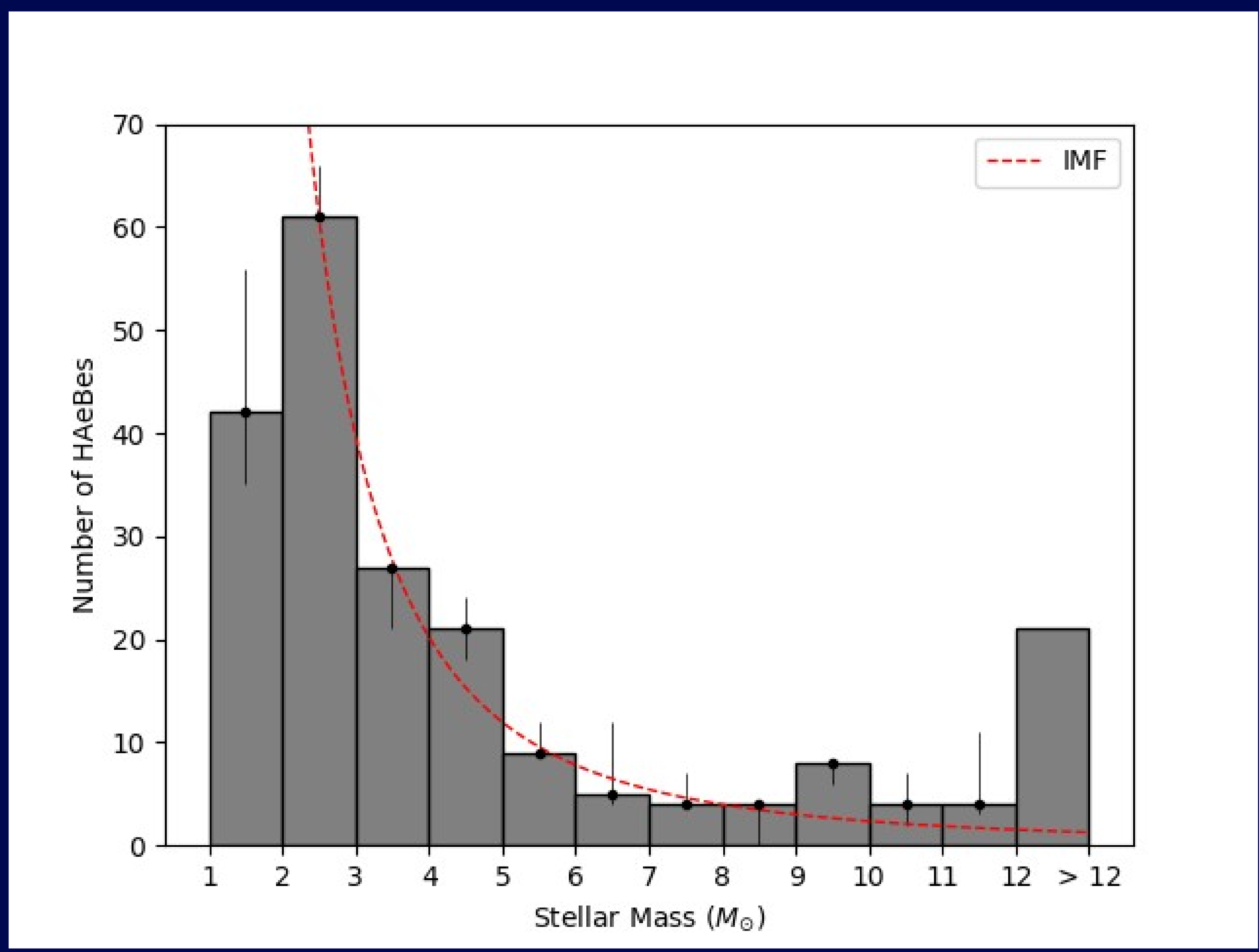

Figure 2: Number of HAeBes vs stellar mass. The solid black lines are the error bars. The dashed red line corresponds to the Salpeter's Initial Mass Function (Salpeter, E. E. 1955, ApJ, 121, 161), normalized to the bin 2-3 $M_\odot$. It can be observed the distribution of stellar masses represents the IMF well if the first and last bin are omitted. According to the IMF, the bin 1-2 $M_\odot$ should be populated with many more HAeBes, but that is the boundary with the T-Tauri regime. Stars with M>12 $M_\odot$ are all grouped together in the last bin.

Preliminary results

A statistical study has been made to find evidences of disk evolution, relating the stellar and disk parameters with both SED classification schemes. Some of our results are:

- A two-sample Kolmogorov-Smirnov test reveals that *Group* Ks HAeBes are typically younger, brighter and more massive than *Group* JH HAeBes. This could be explained taking into account the photoevaporation scenario: the hotter the star, the larger amount of UV photons it emits and, therefore, the dispersion of material is more efficient in its near environment.
- No correlation was found between the derived stellar parameters and the Meeus classification. Also not between the mass accretion rates and both SED classifications; this result contrasts with a previous analysis based on a smaller number of HAeBes (Mendigutía et al. 2012)
- The dust opacity index beta, necessary to derive disk masses from continuum emission and related to the dust grain size, is typically larger in *Group* I sources than in *Group* II. This is in agreement with previous results (Acke et al. 2004) and indicates significant grain growth from *Group* I to *Group* II. The disk masses also decrease towards Group II sources.

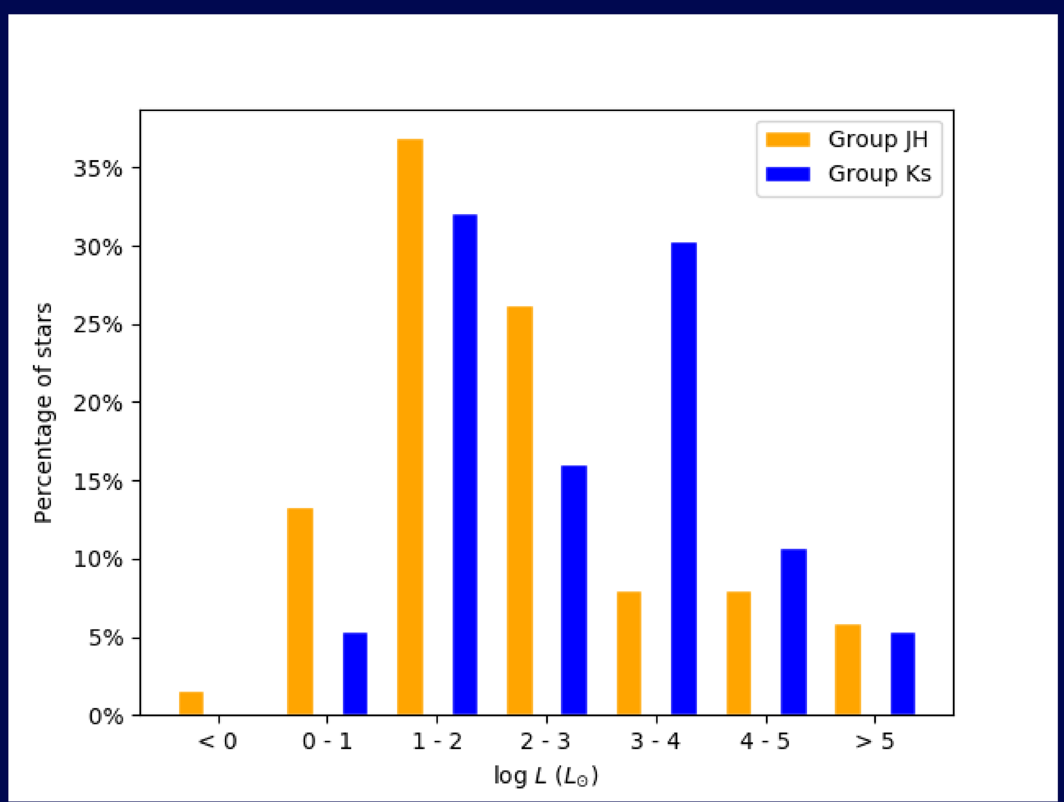

Figure 3: Percentage of HAeBes vs stellar luminosities. *Group* Ks HAeBes tend to be brighter than *Group* JH.

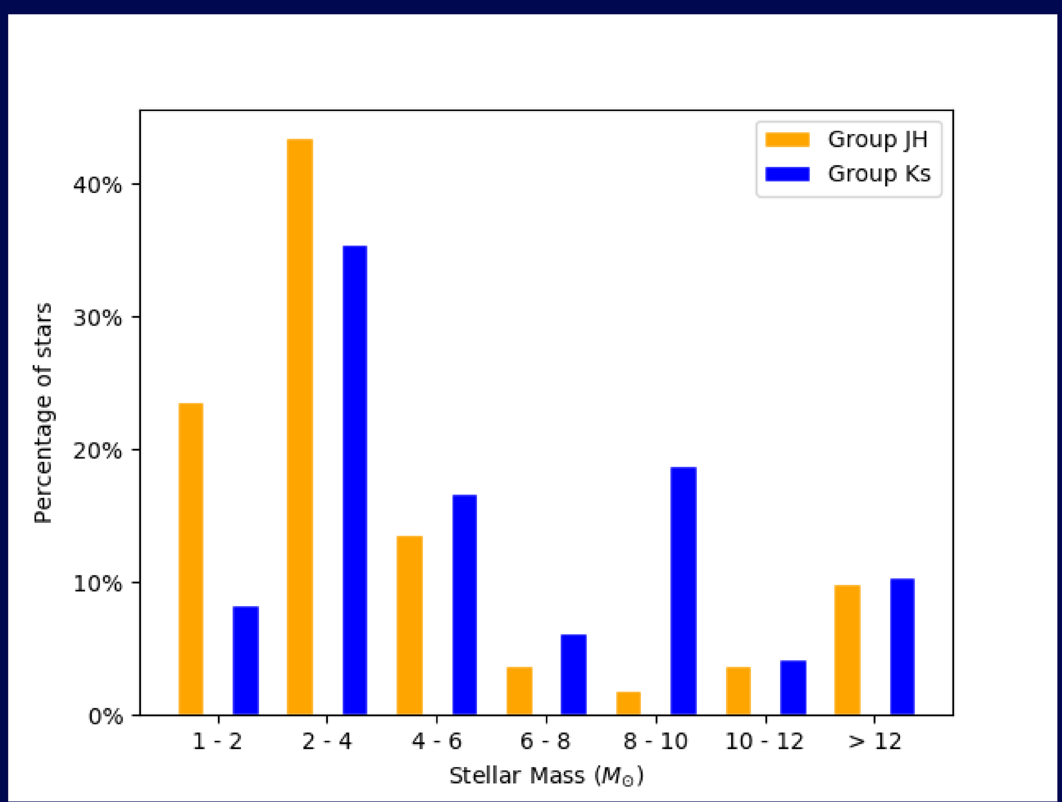

Figure 4: Percentage of HAeBes vs stellar masses. Massive stars tend to belong to *Group* Ks.

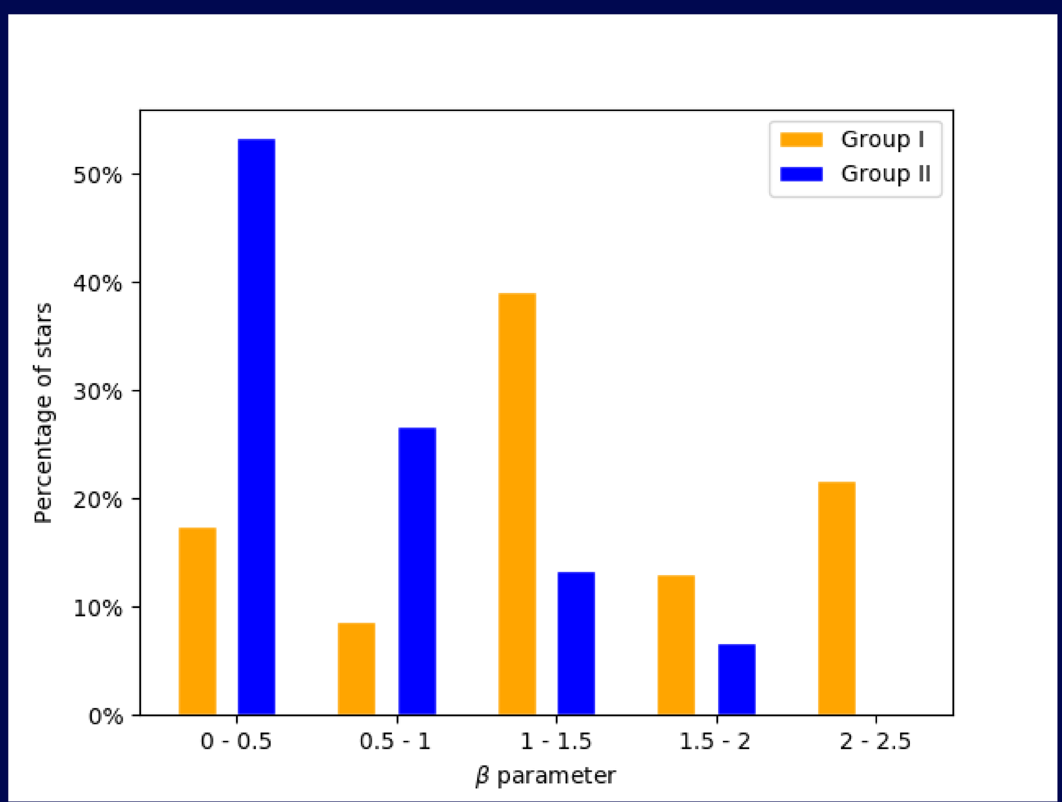

Figure 5: Sub-sample of 39 HAeBes for which the β-parameter has been determined. Smaller β parameters are associated to larger dust grain sizes in the disks, which tend to be shown by *Group* II HAeBes.

Future work: In the short term, we will publish these and several other statistical results linking the stellar and disk properties of HAeBe stars, aiming at setting a proper evolutionary path. In the long term, we aim at connecting the disk properties with the metallicities of the hosting stars, which may be clue to determine possible links with planet formation (Kama et al. 2015, A&A, 582L, 10).

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4. http://svo2.cab.inta-csic.es/vocats/SVOCat-doc/
5. http://svo2.cab.inta-csic.es/theory/vosa/

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