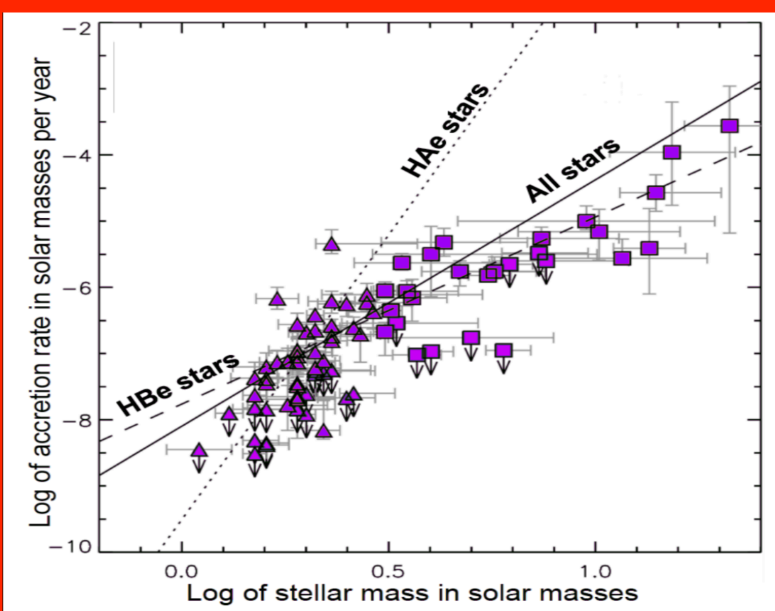
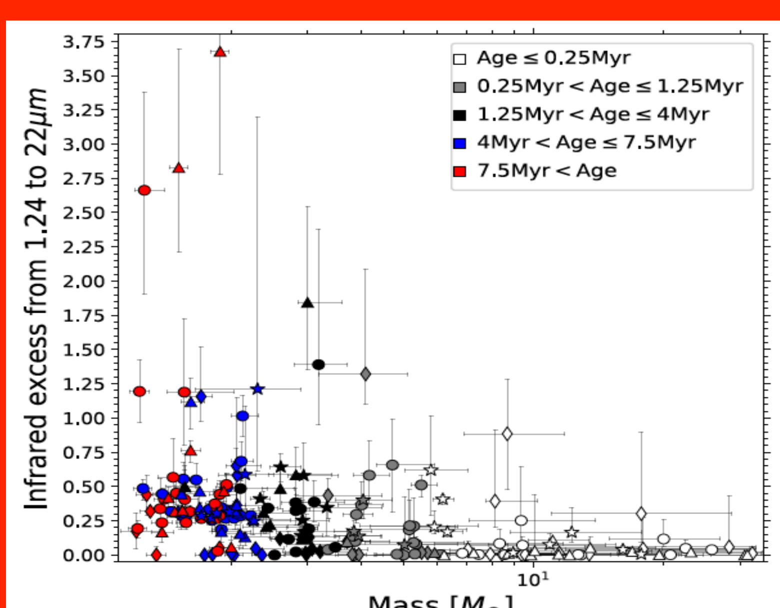
The formation and evolution of Herbig Ae/Be stars

René Oudmaijer, John Fairlamb, Karim Ababakr (Leeds)
Miguel Vioque, Alice Pérez Blanco (Leeds/Isdefe, Madrid)

Intro: The formation mechanisms of low mass stars and high mass stars show large differences as well as similarities. In the intermediate mass range we can expect the formation scenario to switch from magnetically controlled accretion, at low masses, to the massive star forming mechanism - whichever that may be. Understanding the properties of young stars with masses in between will be critical in pinpointing the mass at which the switch. The intermediate mass pre-Main Sequence Herbig Ae/ Be stars are the ideal object class to study this problem.

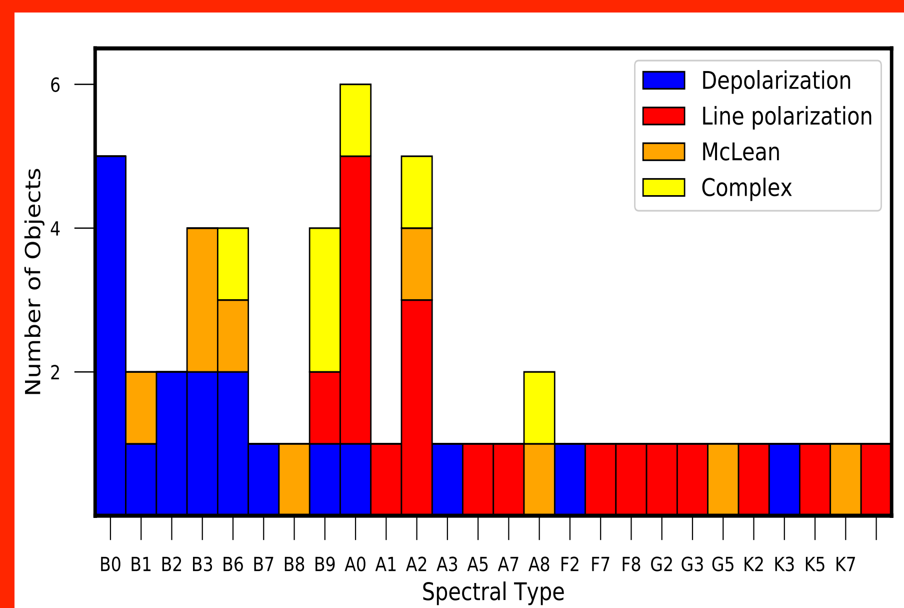


Above left: Accretion rates determined from UV-excess emission in the X-shooter spectra. The accretion rate is different for Herbig Ae than for Herbig Be stars (Fairlamb et al. 2015, 2017). The break is around 2-3 solar masses.



Bottom left: Infrared excess emission as function of mass derived homogeneously from GAIA DR2 data (Vioque et al. 2018). The higher mass objects show hardly any excess. The break is around 7 solar masses.

Our work: Here we present the results of three of our recently completed surveys and mention one on-going large study. These are **1)** an X-Shooter spectroscopic survey of 90 objects. The data, covering the blue to NIR, are used to derive fundamental properties of the stars and their accretion rates in a homogeneous manner. **2)** A linear spectropolarimetric survey of 56 objects probing geometries at scales of order several stellar radii, and **3)** a GAIA DR2 study of >200 stars. In all cases these concern the largest such samples studied thus far.



Above Right: Spectropolarimetric properties versus spectral type. **Hα** line depolarization, probing disks reaching close to the star, occurs for the Herbig Be stars, while line polarization, tracing line emission scattering off a disk, occurs for lower mass, Herbig Ae and T Tauri stars (Ababakr et al. 2017). The Herbig Be objects are surrounded by (accretion) disks reaching onto the stars, whereas the Herbig Ae stars are very similar to the T Tauri stars, which can be explained by magnetospheric accretion. The break occurs around 3 solar masses.

Summary:

- Various studies indicate that Herbig Ae stars are different from Herbig Be stars. Observations relating to the accretion process show a break in properties, and thus accretion mechanism around 3 solar masses. In other words: Herbig Ae stars are like T Tauri stars and may form in the same, magnetically controlled, way. The accretion mechanism for the higher mass objects is unknown but may be related to the Boundary Layer mechanism.
- The break in IR properties is at higher masses, and relates to the dust dispersal mechanism which acts at much larger size scales than the accretion traced by the UV-excess and hydrogen recombination line emission.
- We are extending our statistical studies to the clustering properties of these objects following Testi et al. (1999), but now using GAIA DR2 (Pérez Blanco, in prep.).

References: *Ababakr K., Oudmaijer R.D. et al., 2017, MNRAS 472, 854 Fairlamb J., Oudmaijer R.D. et al., 2015, MNRAS 453, 976 Fairlamb J., Oudmaijer R.D. et al., 2017, MNRAS 464, 4721 Testi L., Palla F., Natta A. 1999, A&A 342, 515 Vioque et al. 2018 A&A subm.*

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