Gaia Study on the Formation of Intermediate Mass Stars

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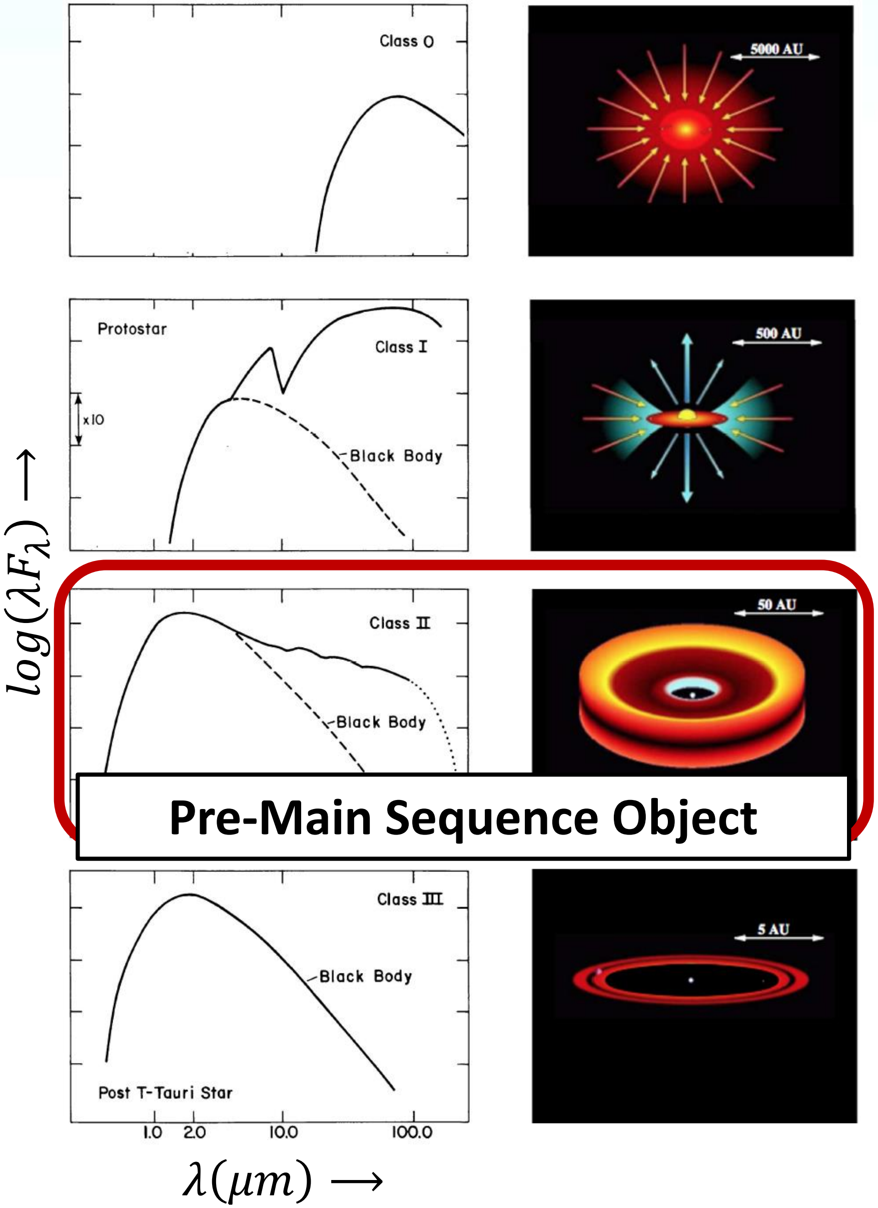
STARRY

STARS THAT 'R' YOUNG

Star Formation in a nutshell



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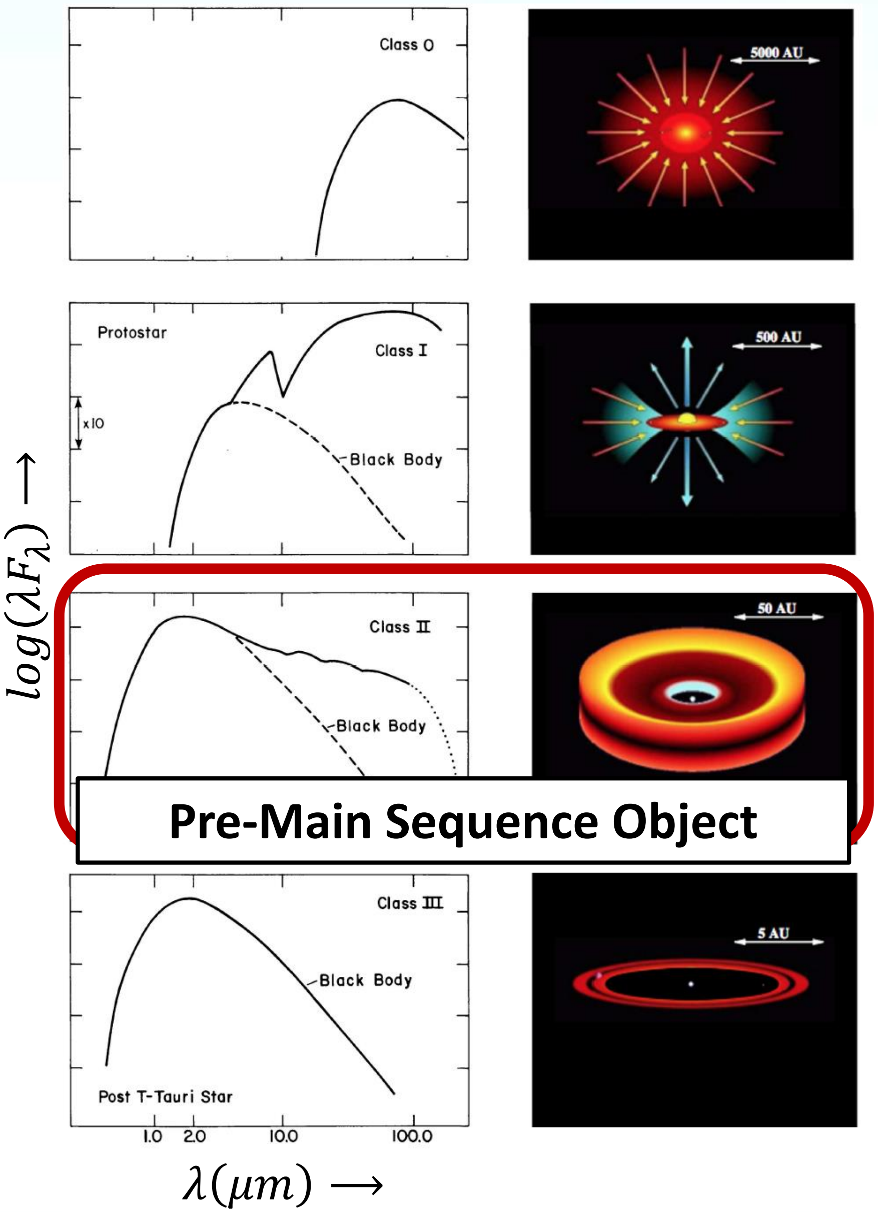

Herbig Ae/Be stars:

- $\gtrsim 1.5 M_\odot$- still optically bright ($\lesssim\ 10 M_\odot$).
- Spectral types ~F7 to B0.

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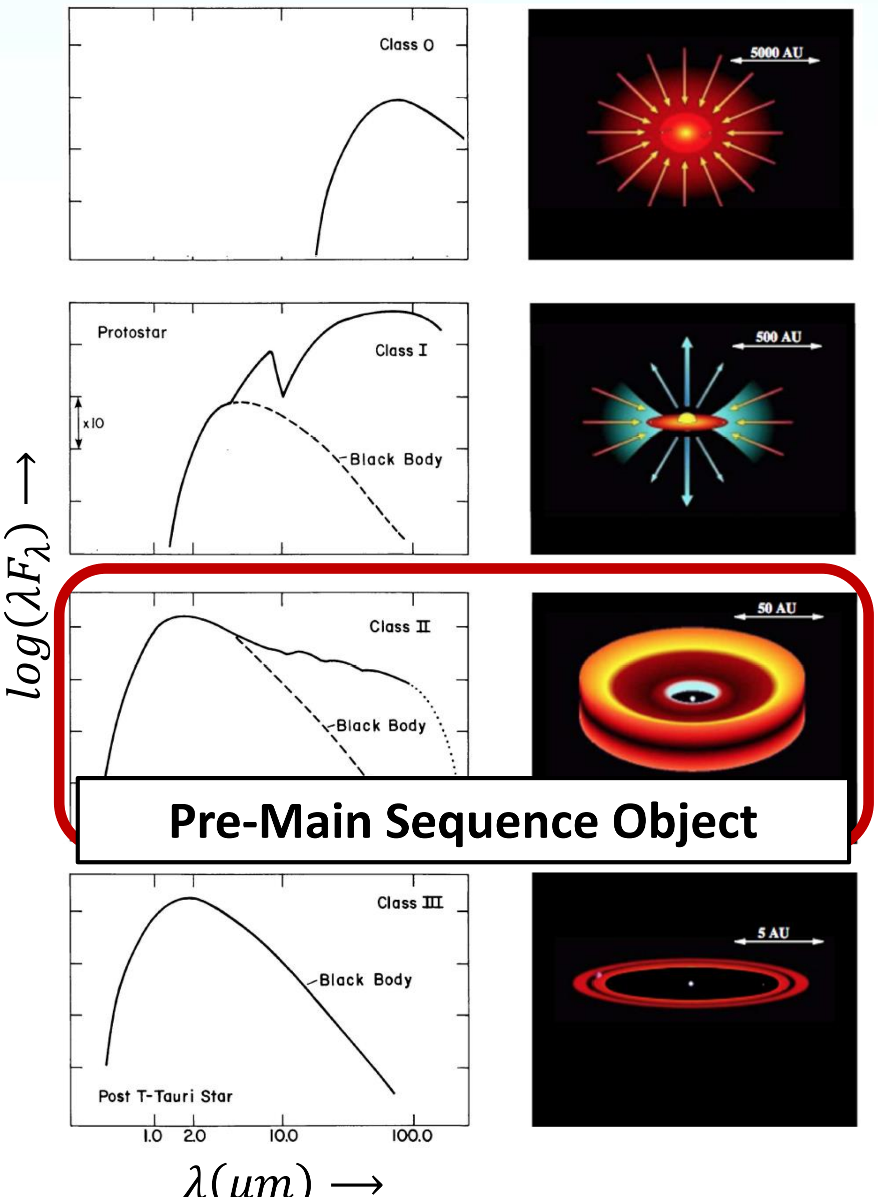

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- Spectral types ~F7 to B0.
- **Present infrared (IR) excess.**
- Present irregular photometric, polarimetric and spectroscopic **variability**.
- $\boldsymbol{H_\alpha}$ is often seen entirely in **emission**.

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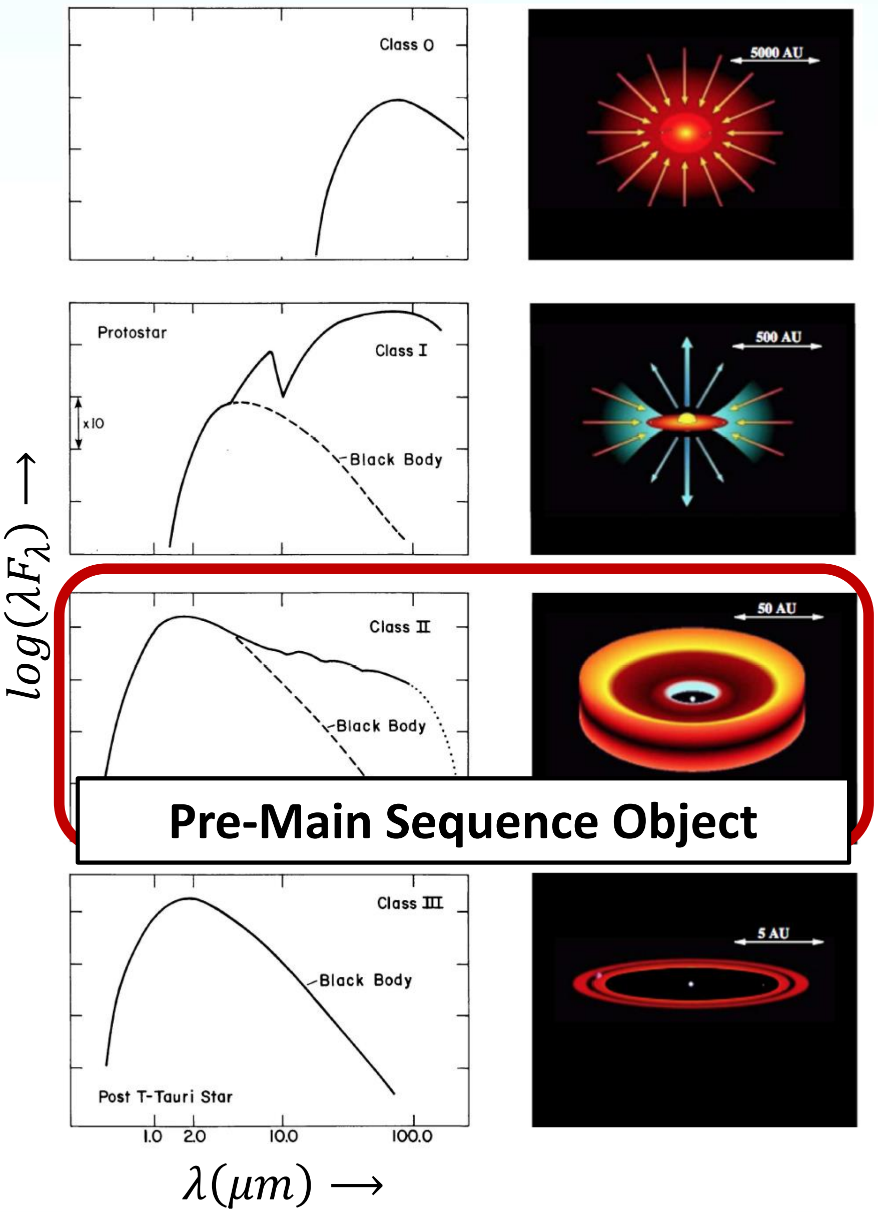

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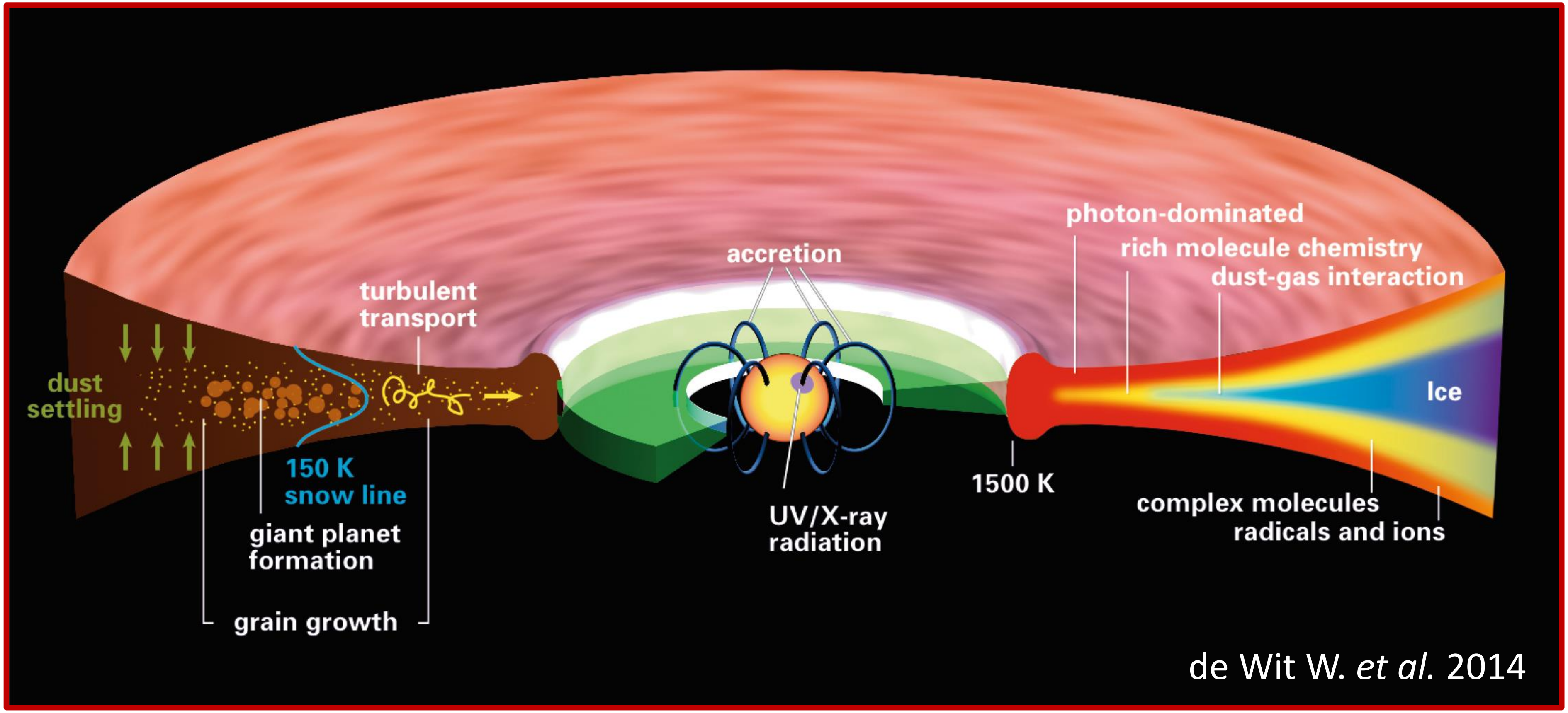
- Present irregular photometric, polarimetric and spectroscopic **variability**.
- H_α is often seen entirely in **emission**.
- **Around 260 candidates known to date.**

Star Formation in a nutshell

Low mass Pre-Main Sequence accretion

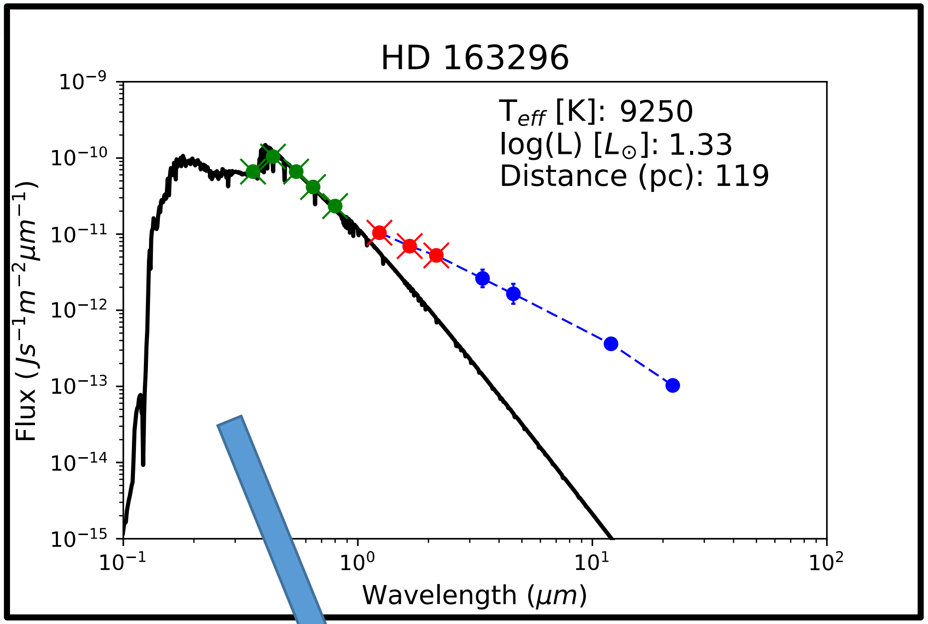


de Wit W. *et al.* 2014

High mass Pre-Main Sequence accretion still largely not understood

The HR diagram

Parallaxes + Total Fluxes ⟶ Luminosities



Luminosity

The HR diagram

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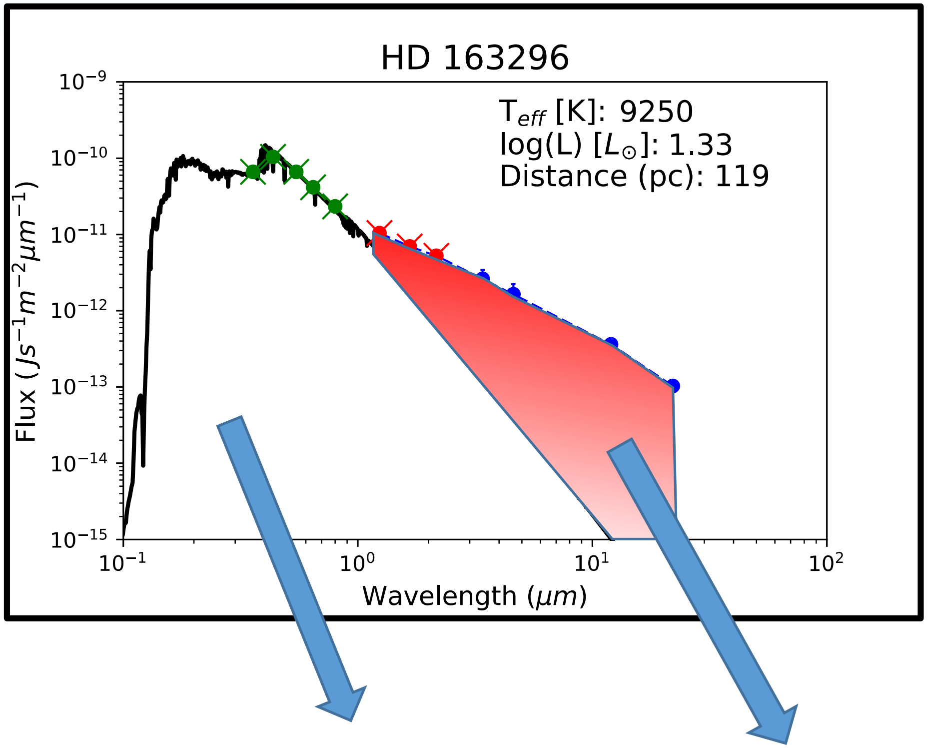

Luminosity **IR excess**

The HR diagram

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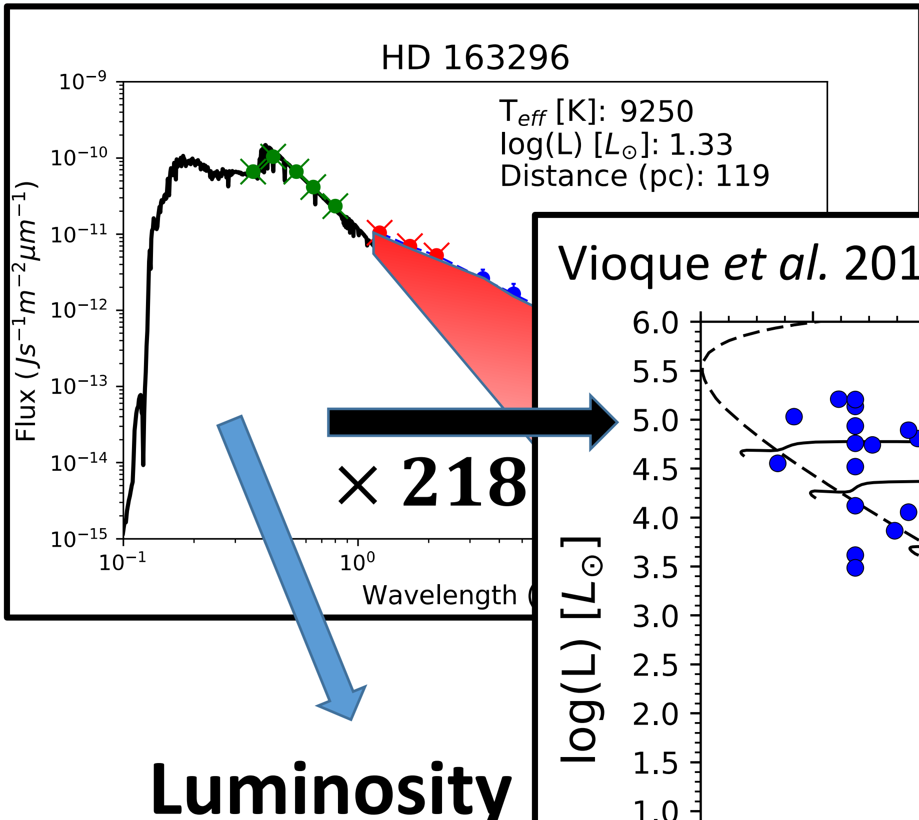

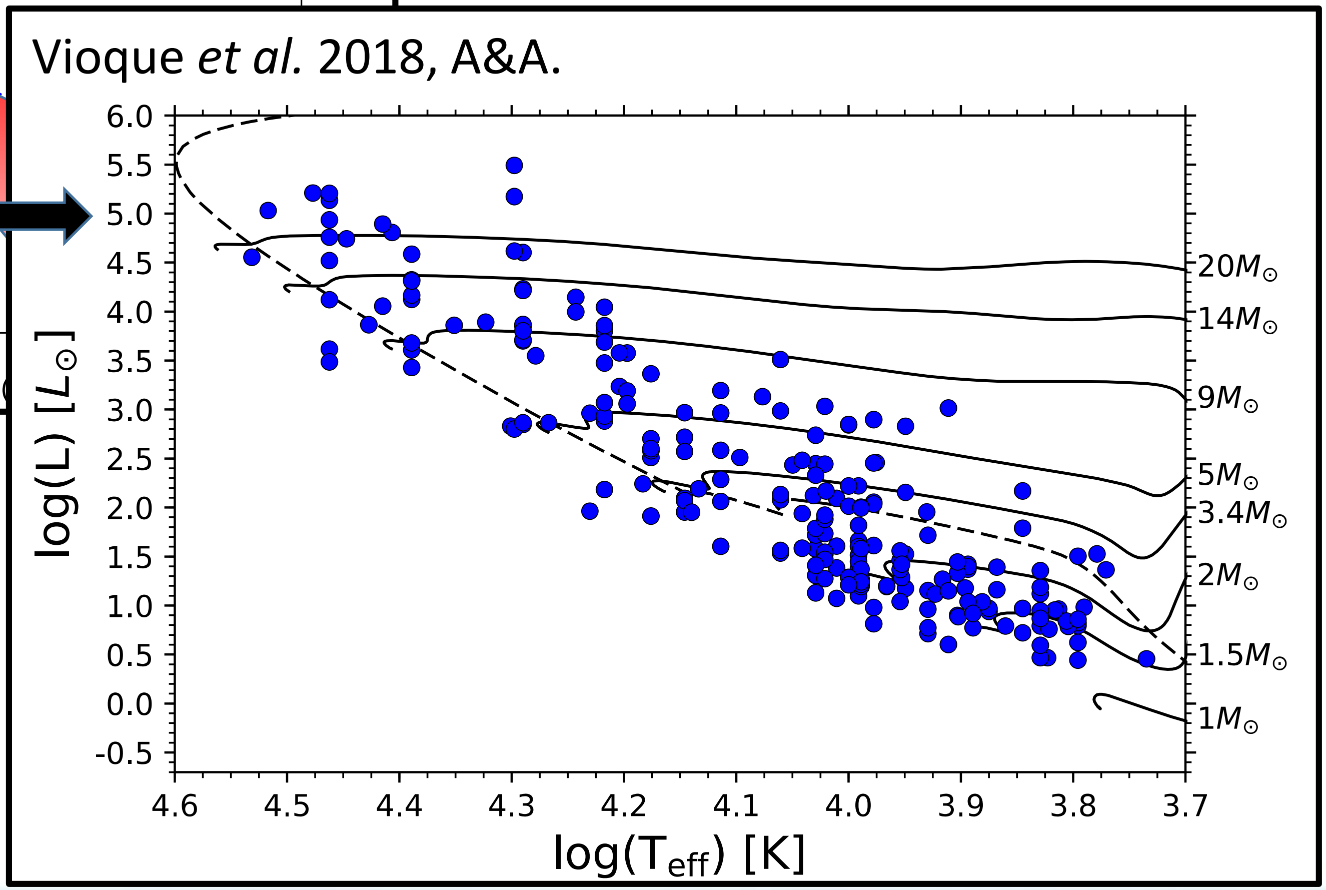

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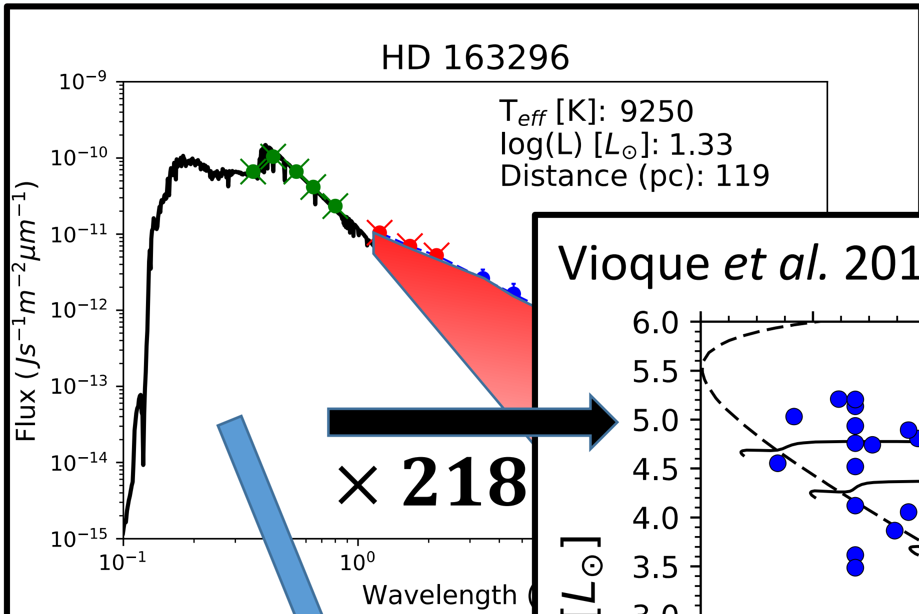
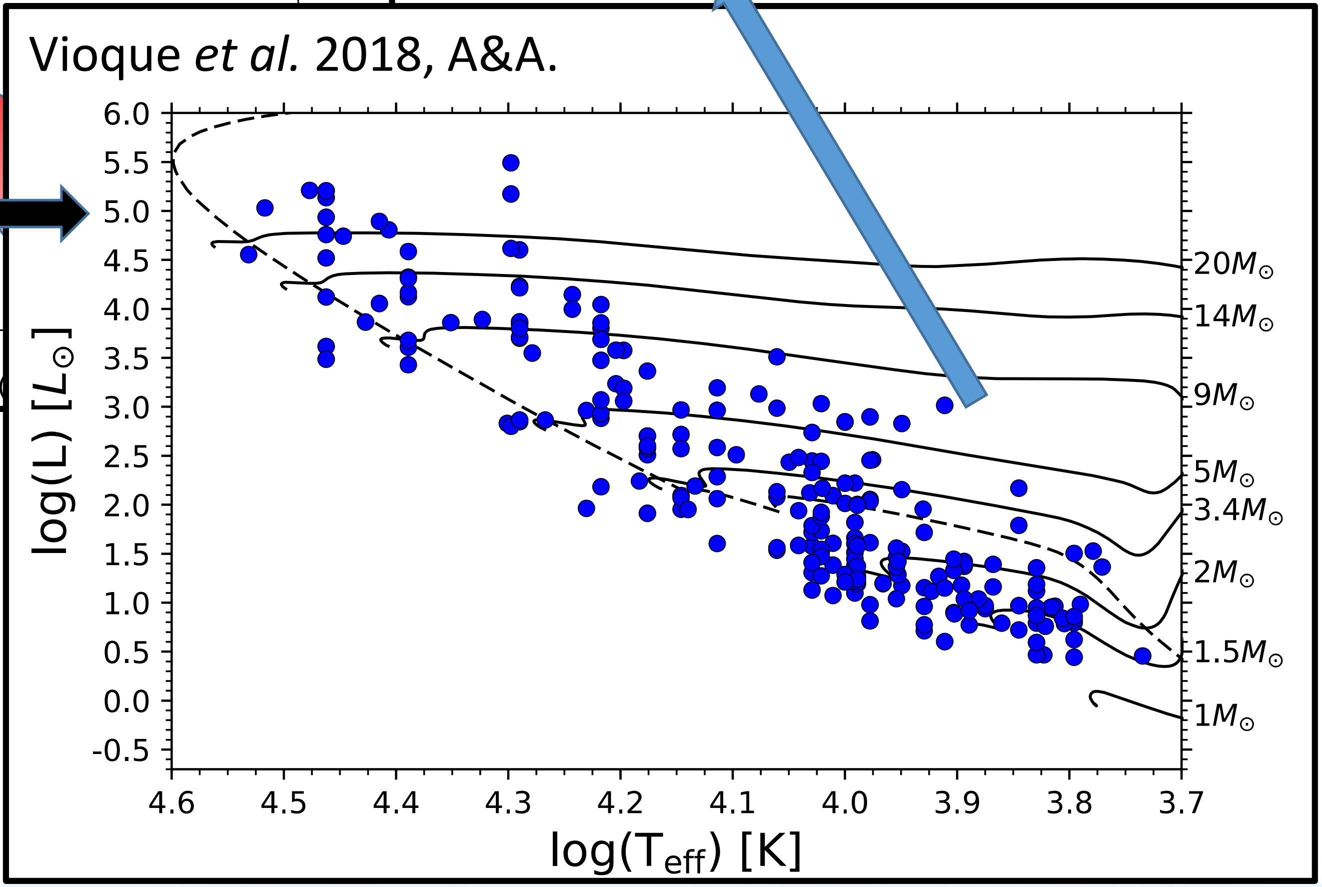
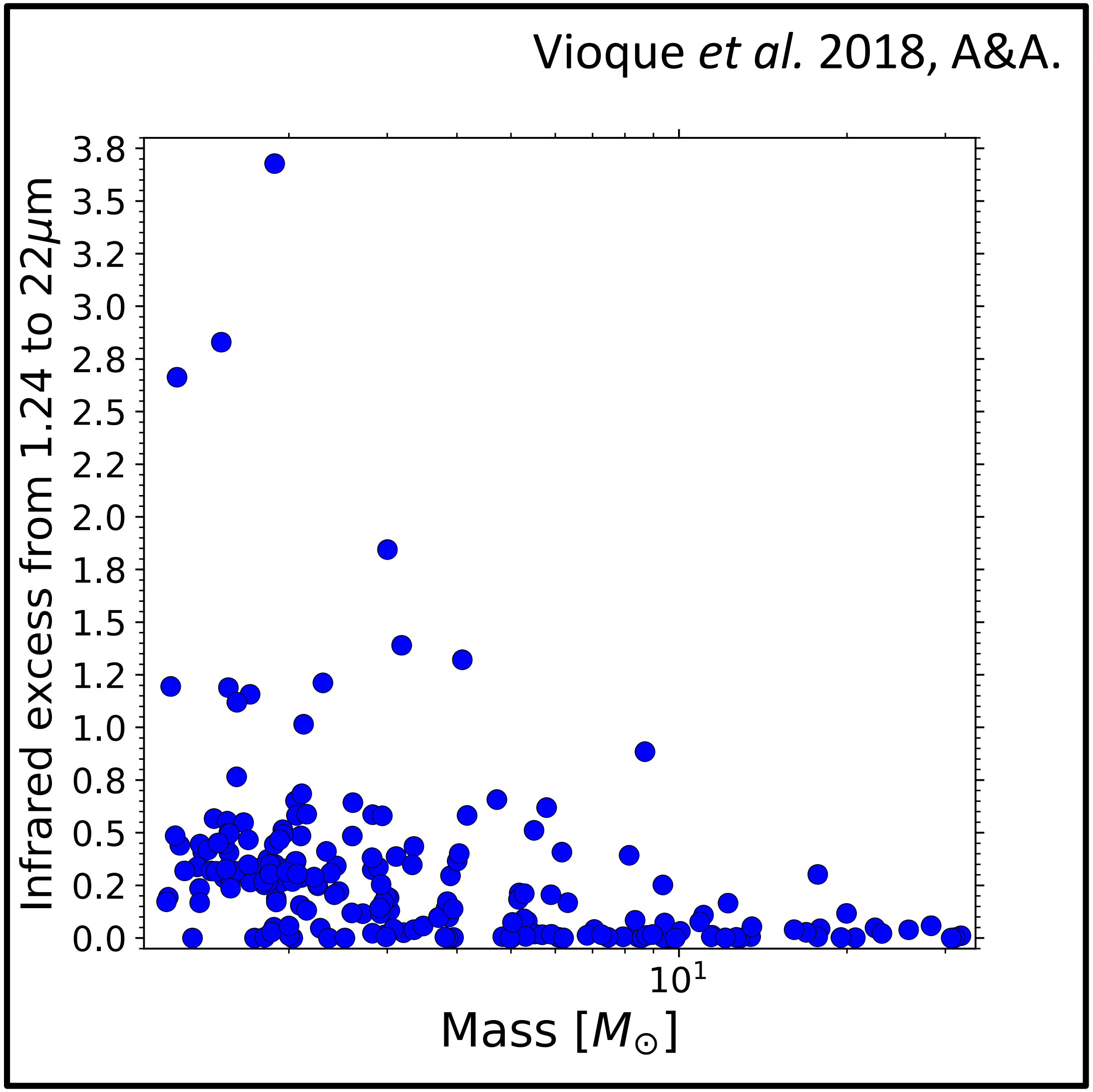


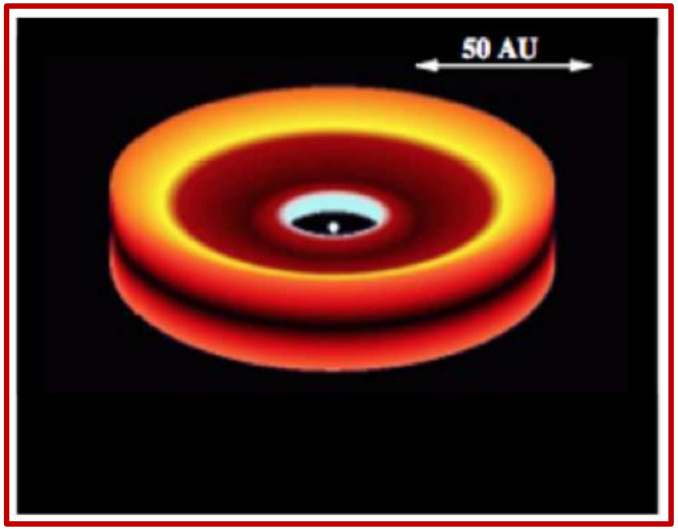
PMS tracks & Isochrones → **Masses**, **Ages**

Luminosity

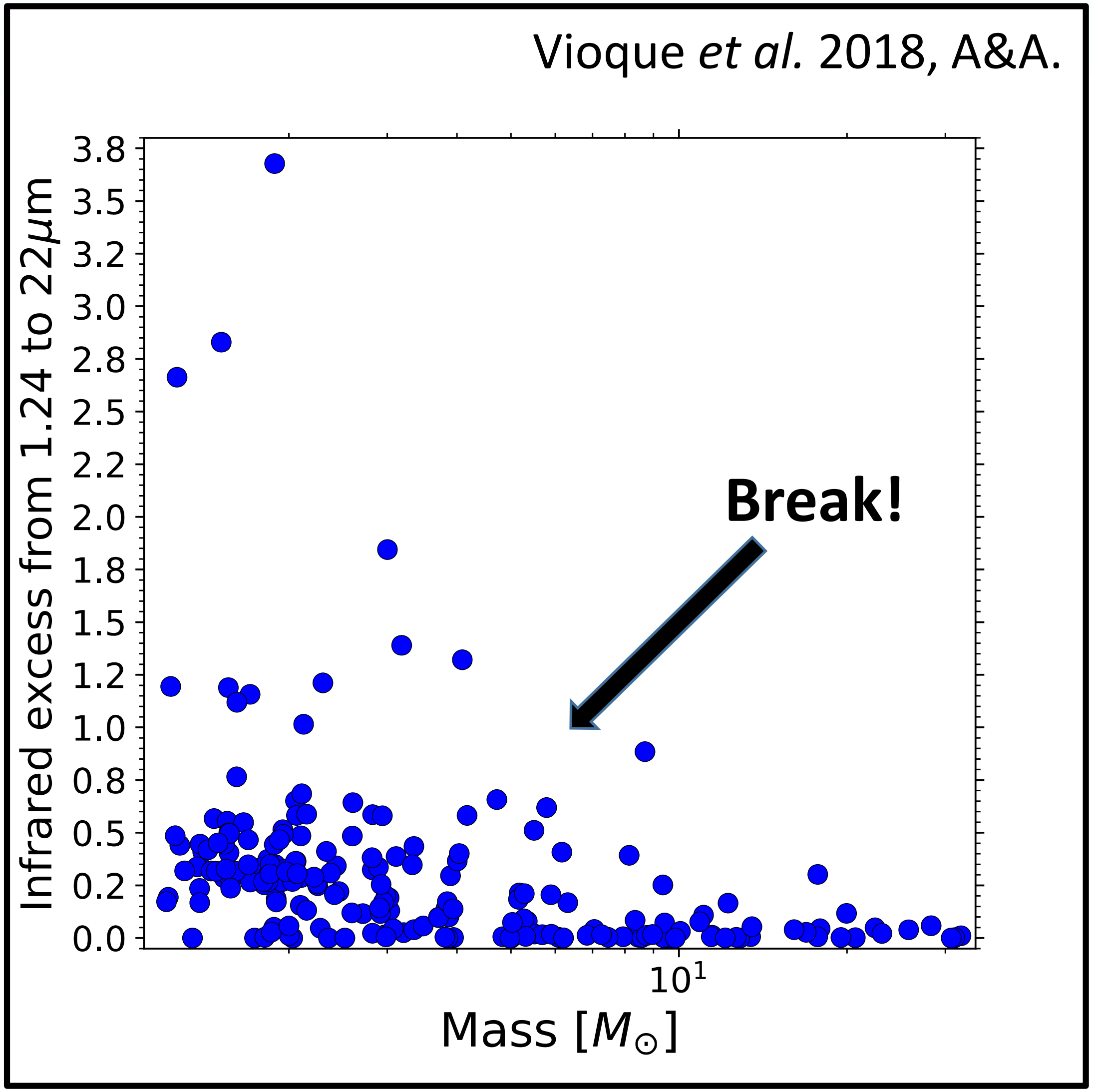


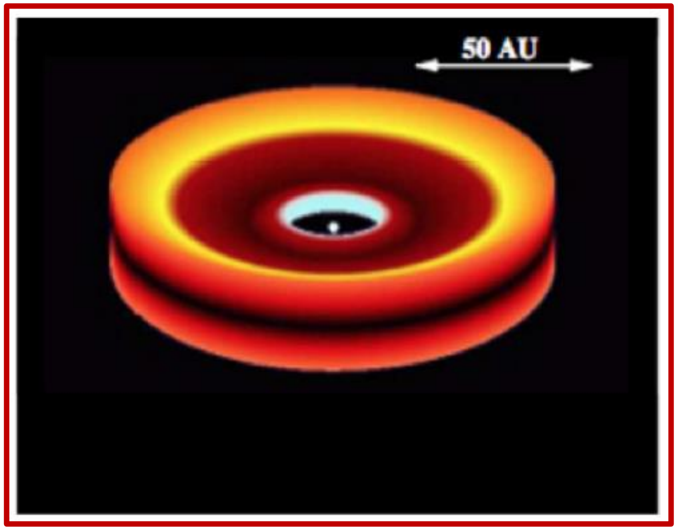
Infrared excess vs. Mass





Infrared excess vs. Mass





There is a break at around $\approx 7M_\odot$. Appears that the dusty disks surrounding Herbig Ae and Herbig Be stars are different.

Variability from Gaia

It is possible to use Gaia's repeated observations to extract photometric variability information.

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Deason *et al.* 2017 variability amplitude:

$$A_i = \sqrt{N_{obs}}\sigma(F_i)/F_i$$

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Variability indicator (V_i): Basically compares the variability amplitude of a Herbig Ae/Be star with that of Gaia objects of similar brightness.

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Deasor
variabi

$/F_i$

$$V_i = 2 \longrightarrow 0.5mag$$
variability (V band)

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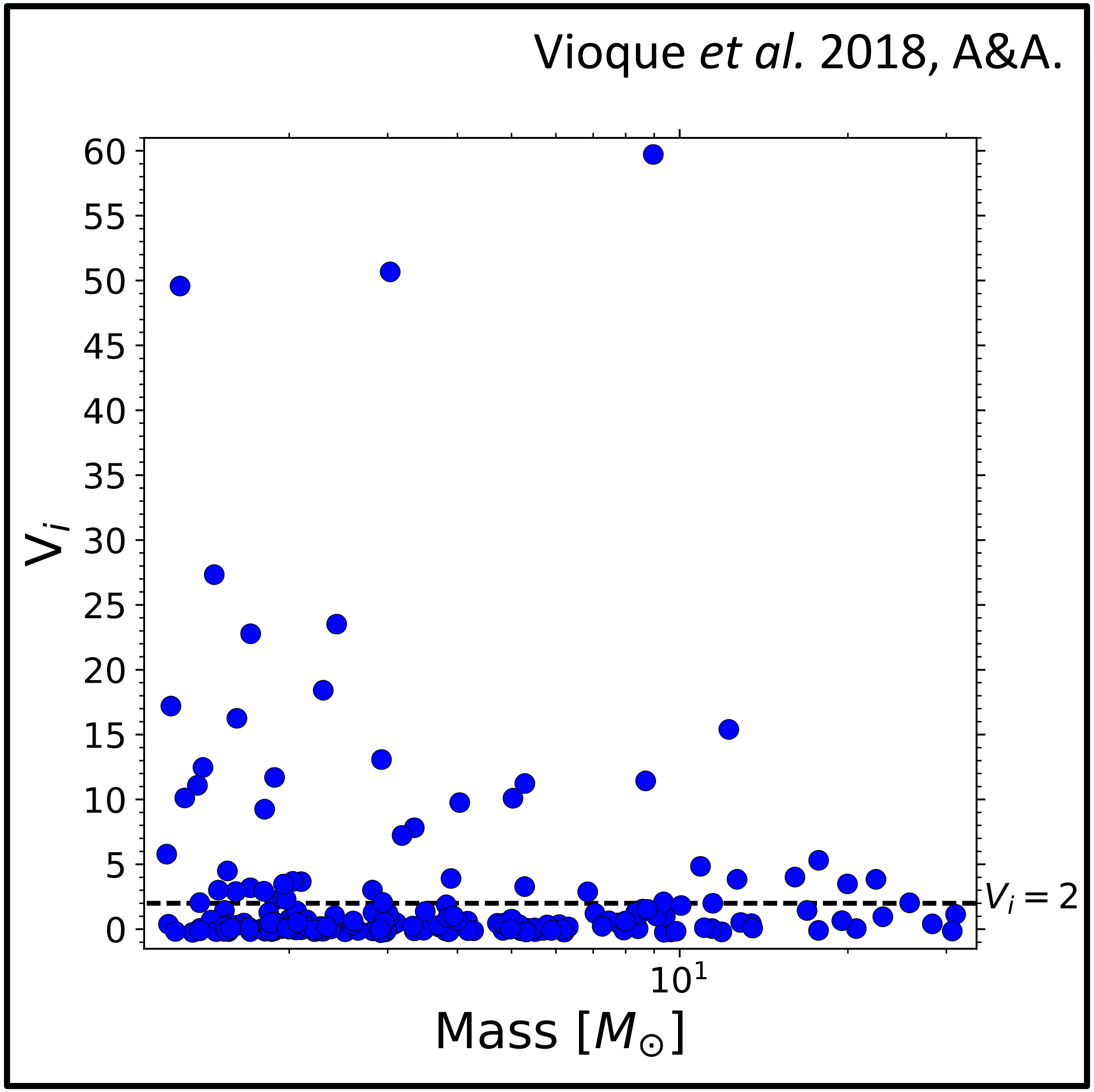
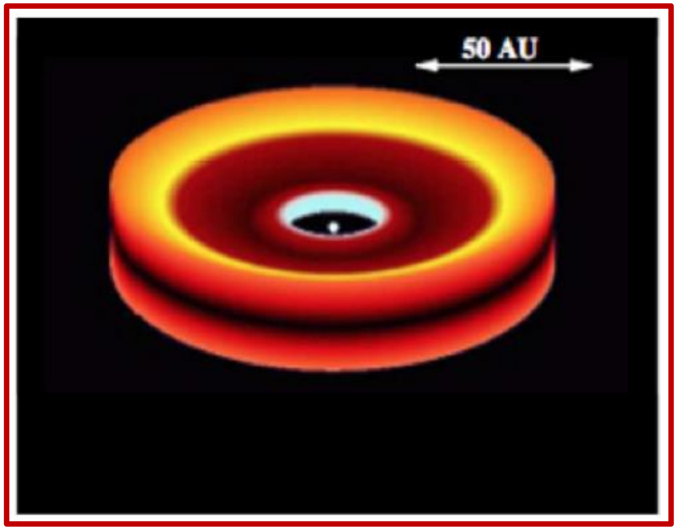
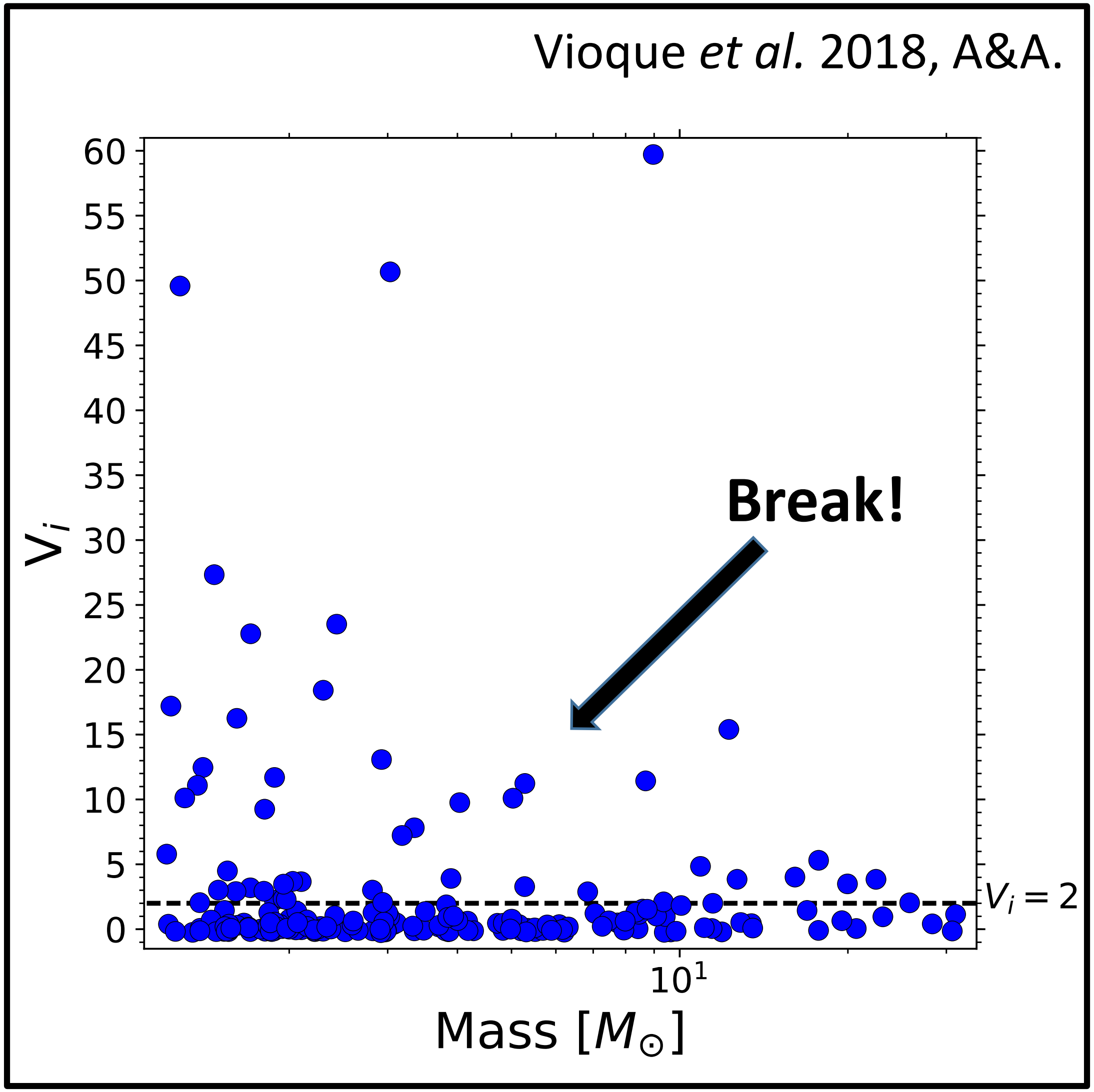
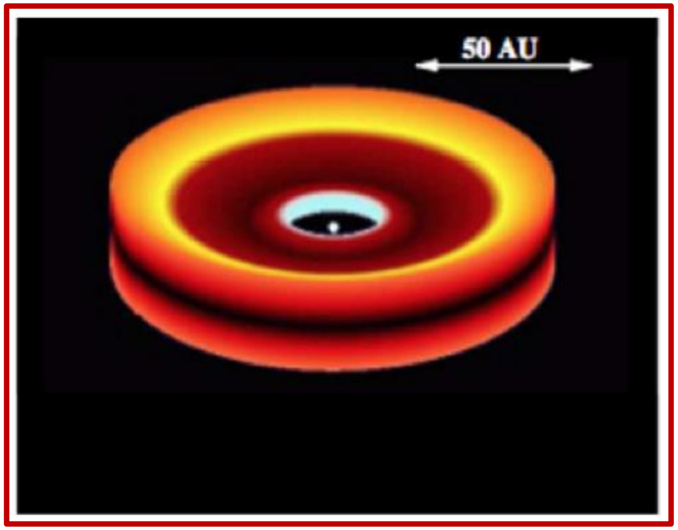
Variability vs. Mass





Variability vs. Mass



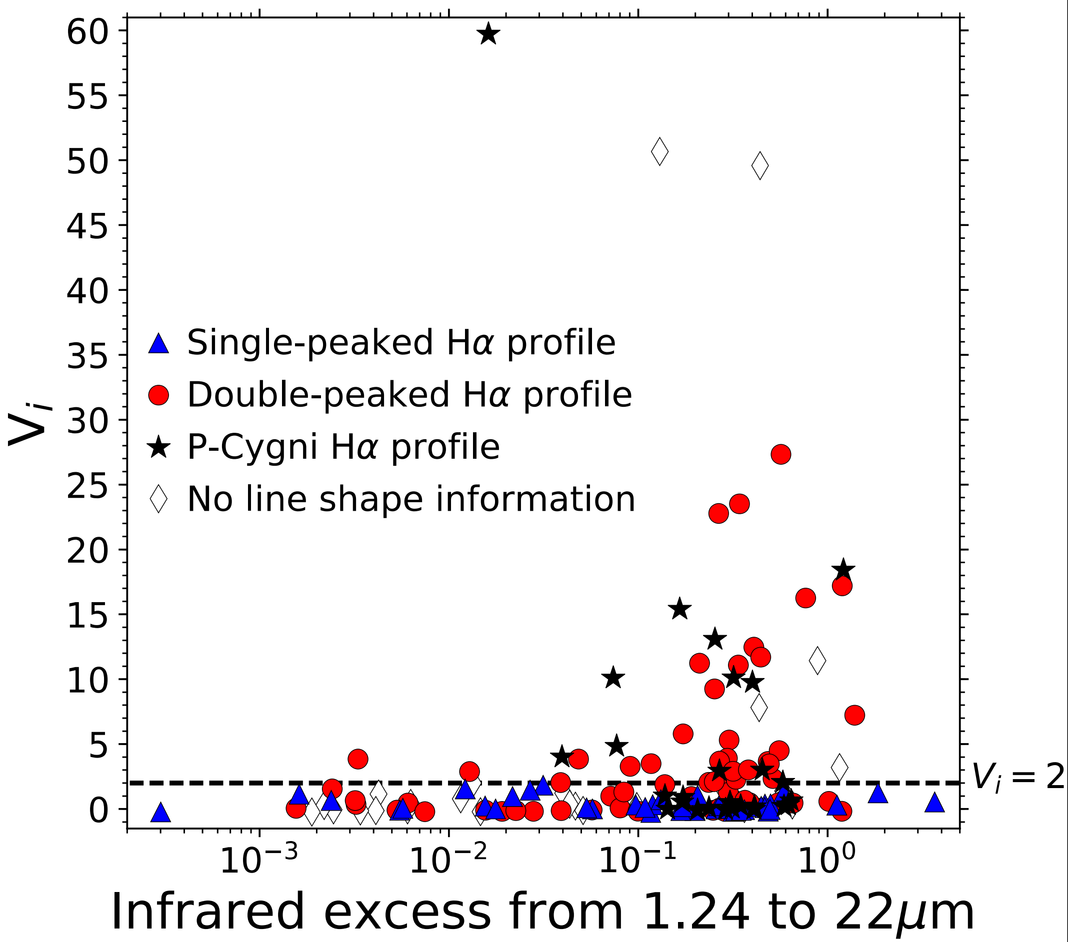


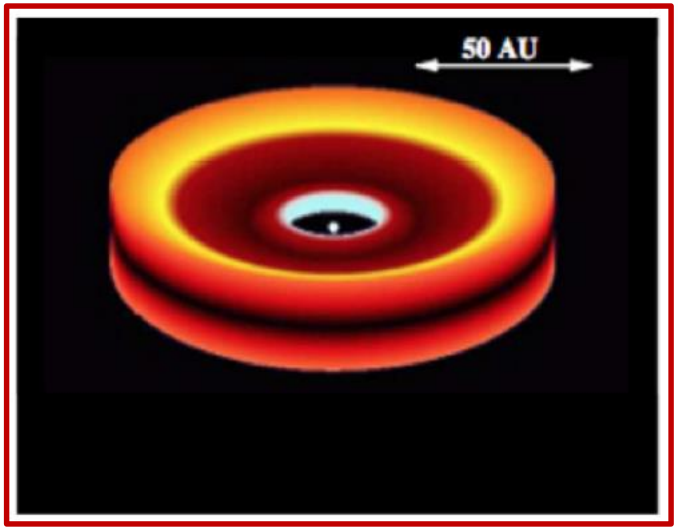
Same break at around $\approx 7 M_\odot$.

~25% of all Herbig Ae/Be stars are strongly variable.

Variability vs. Infrared excess

Vioque *et al.* 2018, A&A.



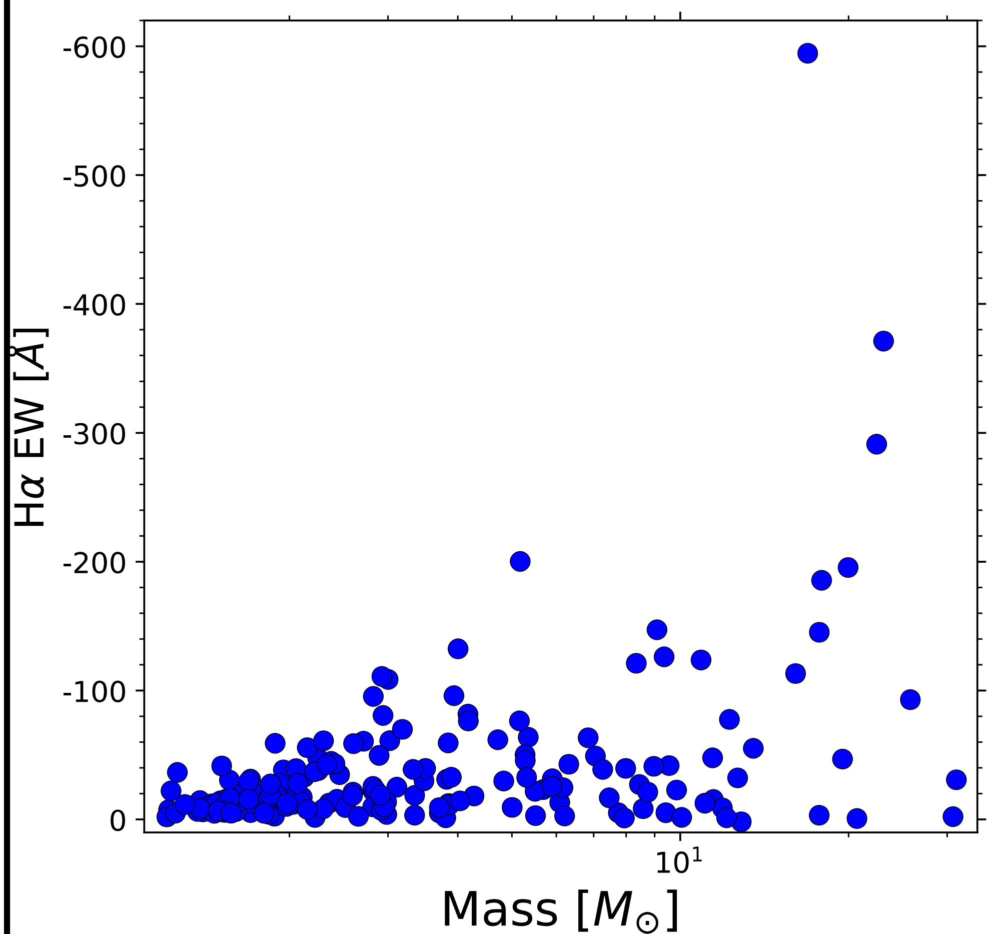


~72% of the strongly variable Herbig Ae/Be stars show double-peaked H_α emission.

None show a single-peaked line profile.

H_α equivalent width vs. Mass

Vioque *et al.* 2018, A&A.



Various **other** H_α line properties seem to differ at a lower mass of $\approx 3M_\odot$.

- Fairlamb *et al.* 2015
- Ababakr *et al.* 2017

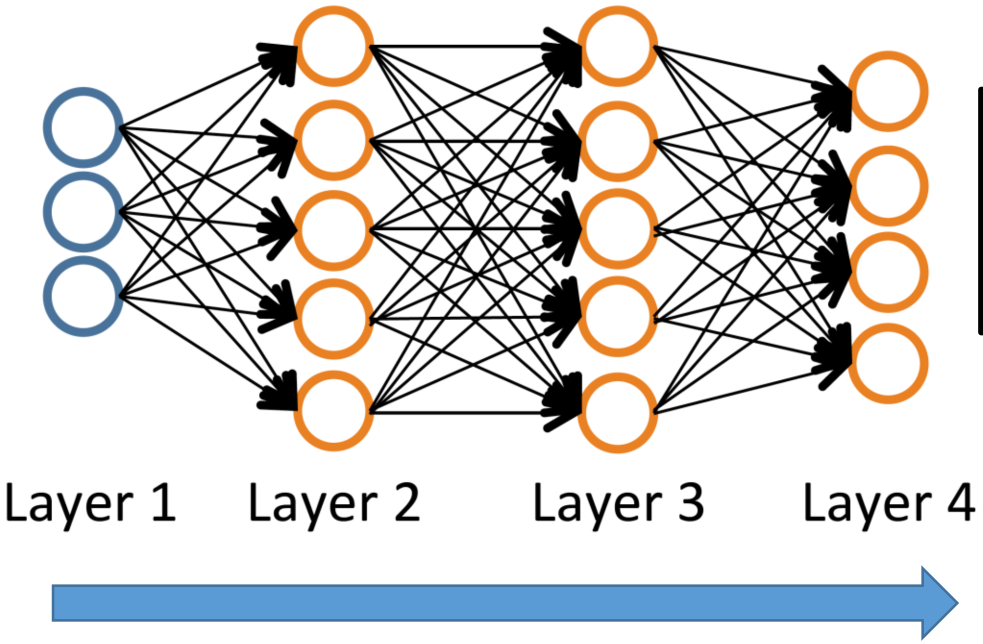
Future work: Finding new Herbig Ae/Be stars

1st step

Algorithm is trained with large accurate data

Input training set:

- IR excess.
- H_α emission.
- Photometric variability.
- **… (11 dimensions)**



Output:
Efficiency of the algorithm.

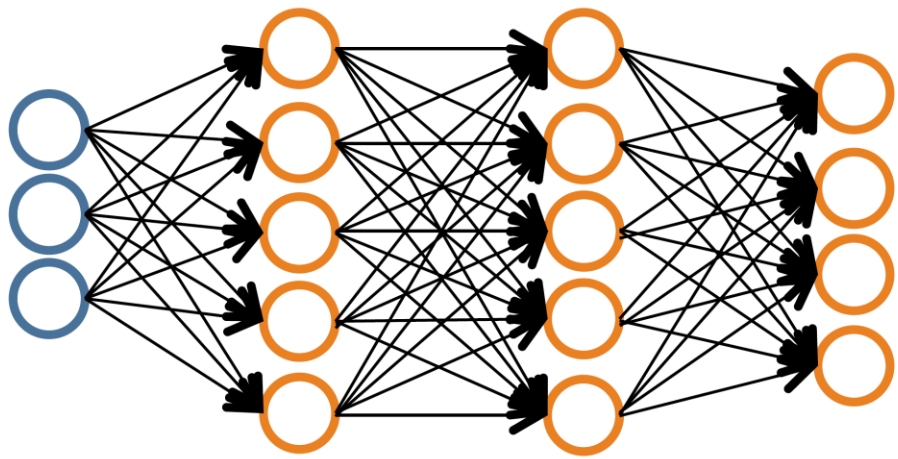
This project has received funding from the European Union's Horizon 2020 research and innovation programme under MSCA ITN-EID grant agreement No 676036.

Future work: Finding new Herbig Ae/Be stars

2nd step

Algorithm runs on new data

Input Gaia sources.



Layer 1 Layer 2 Layer 3 Layer 4

Output:
Probability for every object of being of Pre-Main Sequence type.

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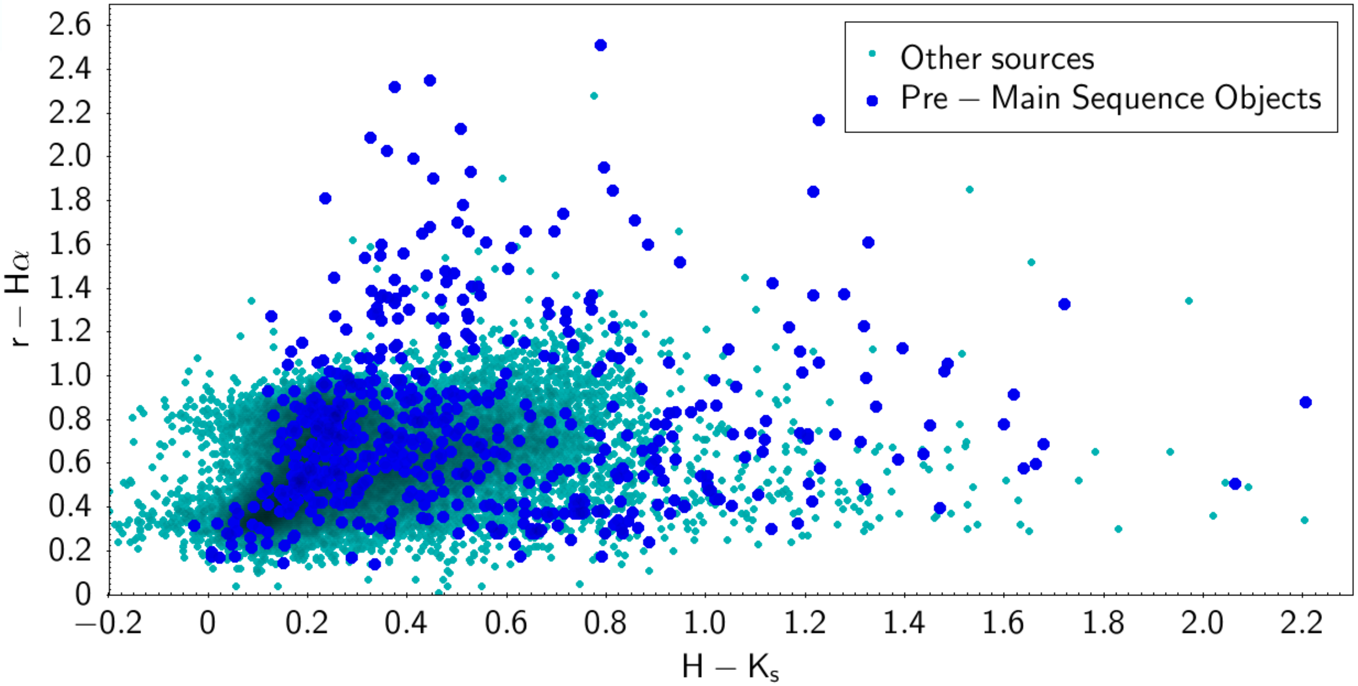
Future work: Finding new Herbig Ae/Be stars



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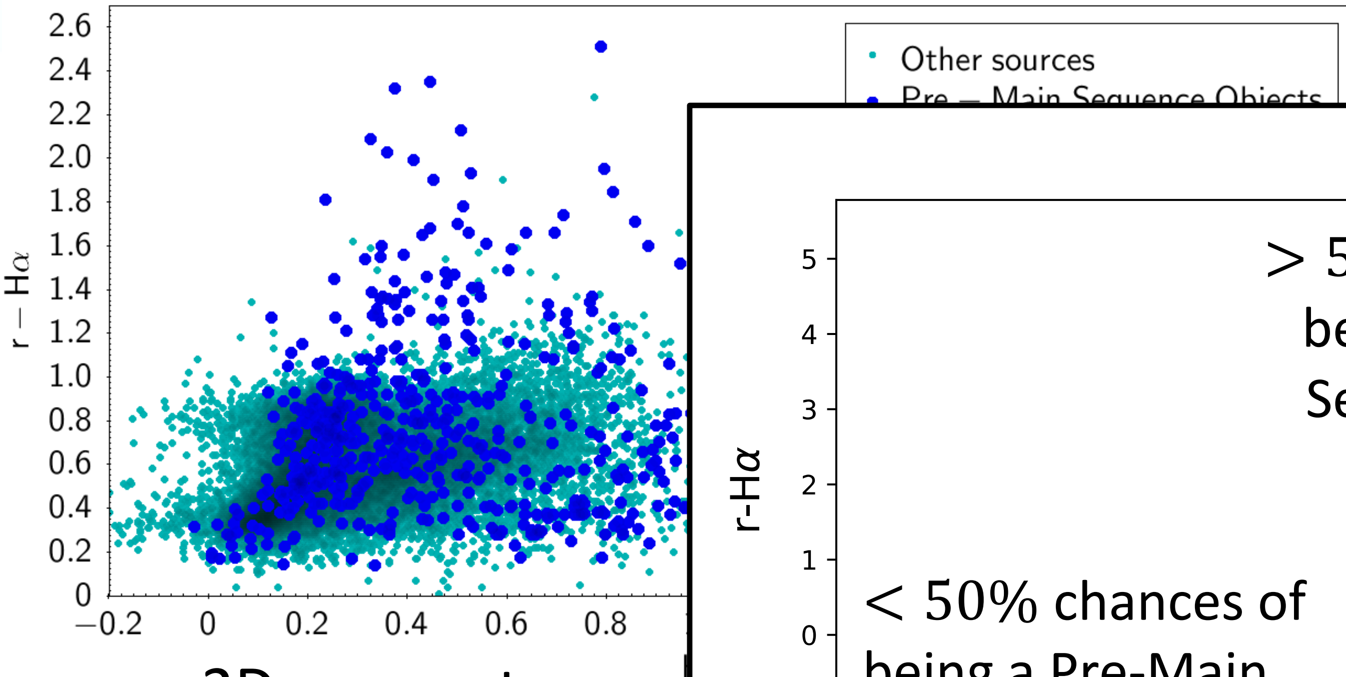
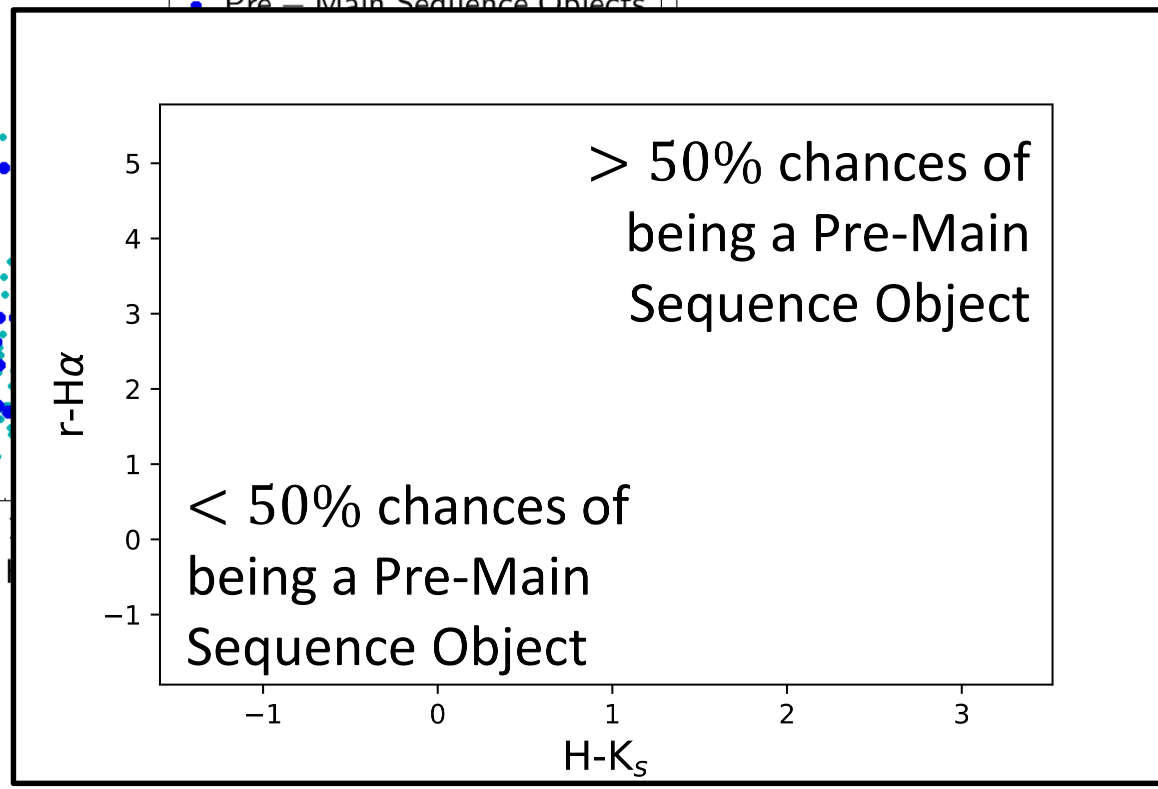


2D parameter space after training



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Conclusions

- We homogeneously derived luminosities, masses, ages, variabilities and infrared excesses for the most complete sample of Herbig Ae/Be stars to date, 252 sources.
- High mass stars do not display an infrared excess and show no strong variability. We do note that break is around $\sim 7M_{\odot}$. Appears that the dusty disks surrounding Herbig Ae and Herbig Be stars are different.
- $\sim 25\%$ of all Herbig Ae/Be stars are strongly variable. The photometrically variable objects are seen edge-on and surrounded by a disk-like structure.

The break in accretion mechanism appears to occur at around $3M_{\odot}$, whereas the disk dispersal becomes significant at higher masses, $\approx 7M_{\odot}$.

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Gaia's view of Pre-Main Sequence Evolution:

Linking the T Tauri and Herbig Ae/Be stars

18 - 21 June 2019

Weetwood Hall, Leeds - UK

p.grant@leeds.ac.uk; https://starry-project.eu/final-conference/

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STARRY STARS THAT 'R' YOUNG

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Information

The STARRY project has received funding from the European Union's Horizon 2020 research and innovation programme under MSCA ITN-EID grant agreement No 676036. Image credit: PanSTARRS

This poster was designed by M.S. Alice Pérez