School of Physics and Astronomy
FACULTY OF MATHEMATICS AND PHYSICAL SCIENCES

GAIA DR2 study on the Formation of Intermediate Mass Stars: *the STARRY project*

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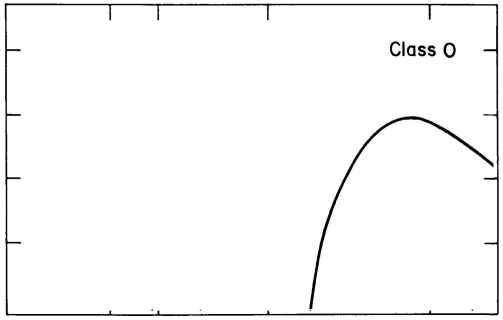
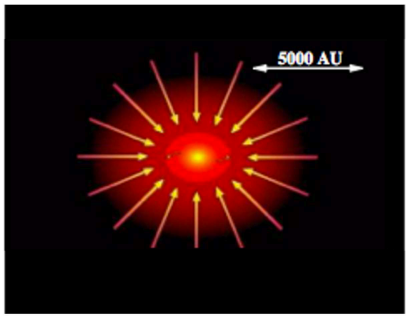
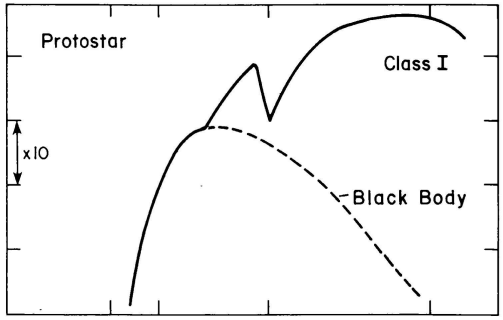
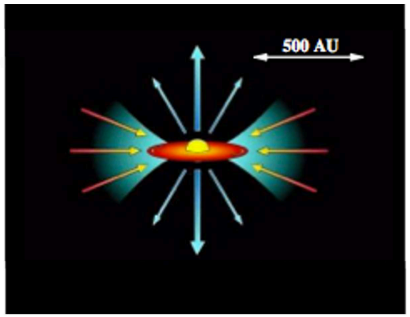
RAS Specialist Discussion Meeting "The Gaia DR2 Astronomy Revolution", London 12 October 2018

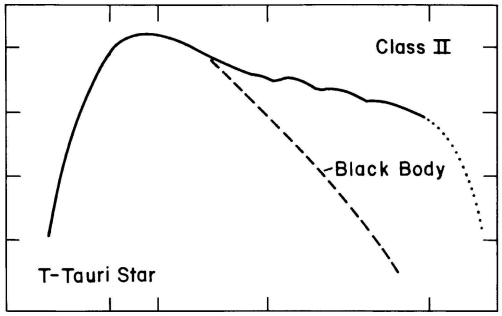
The STARRY project receives funding from the European Union's Horizon 2020 Marie Skłodowska-Curie Actions (MSCA) programme under ITN_EID Grant Agreement No 676036.

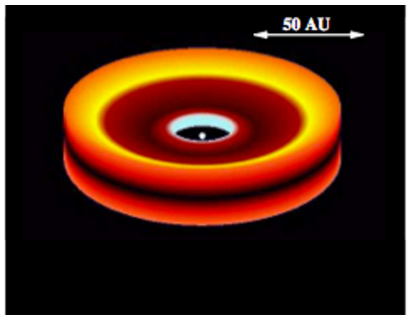


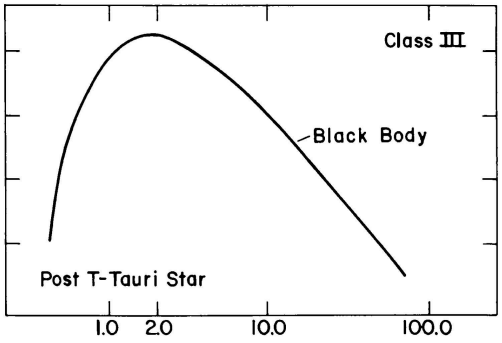


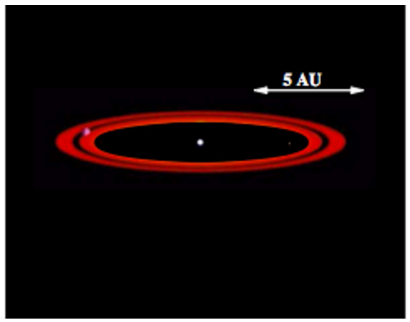












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Low mass star formation fairly well understood.

High mass formation problematic

Van Boekel+ 2004

Pre-main sequence stars

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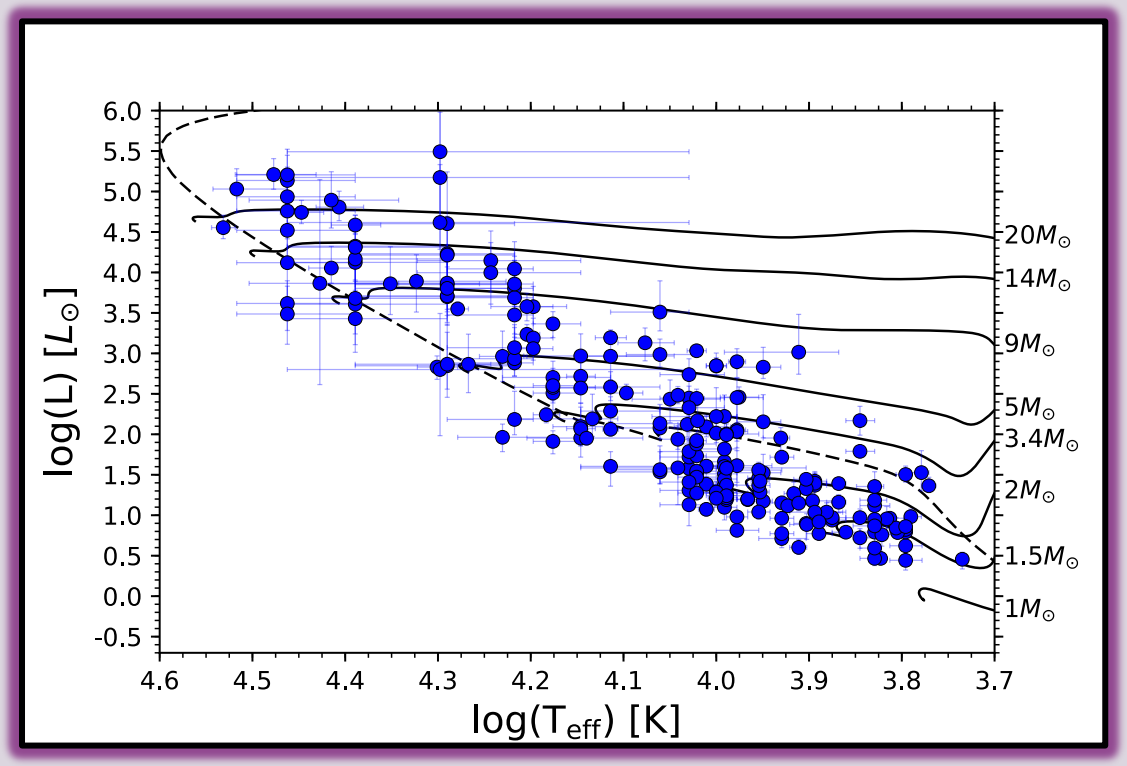
T Tauri stars : solar mass, magnetically controlled accretion, veiling, optically visible

Herbig Ae/Be stars : intermediate mass,

optically visible

Massive Young Stellar Objects : massive, rare, elusive, obscured (Leeds RMS)



Gaia DR2 Vioque+ 2018

Statistical studies: polarimetic

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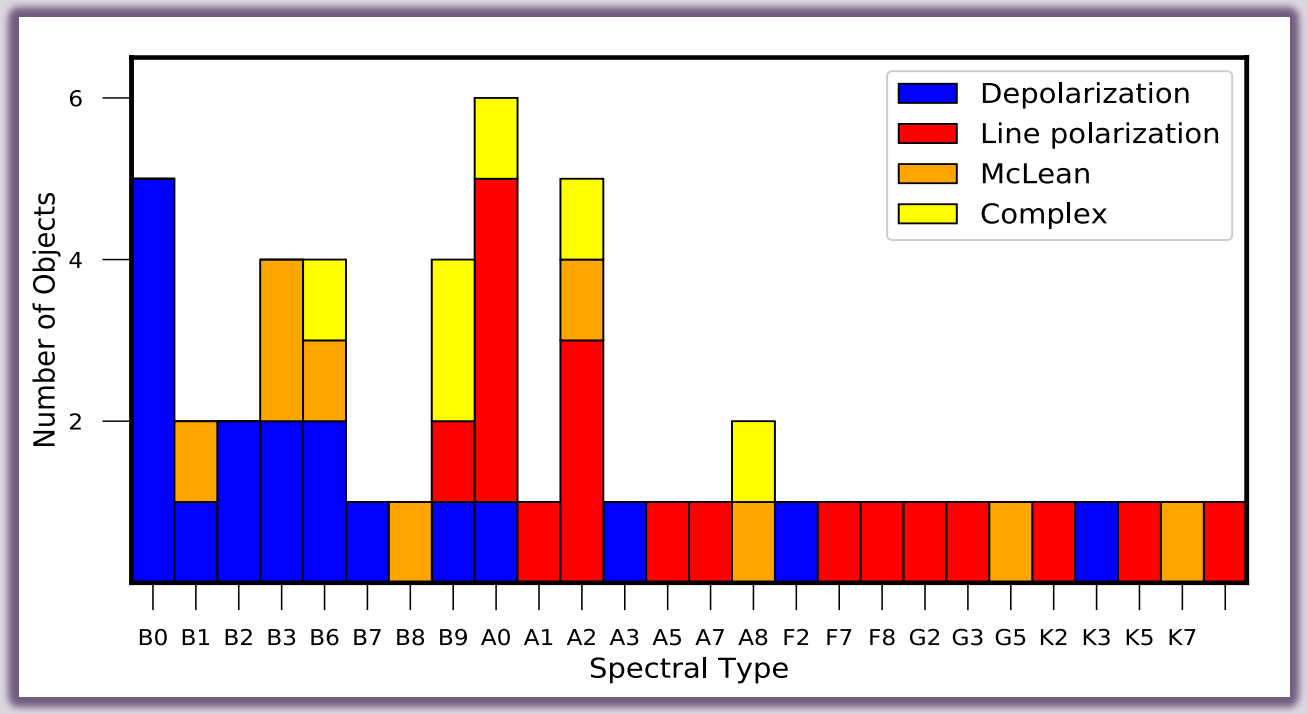

Large sample of 56 objects:
Trend with spectral type
(Ababakr+ 2017)

Break/change in properties around $3M_{\odot}$.

Accretion rate correlates with mass

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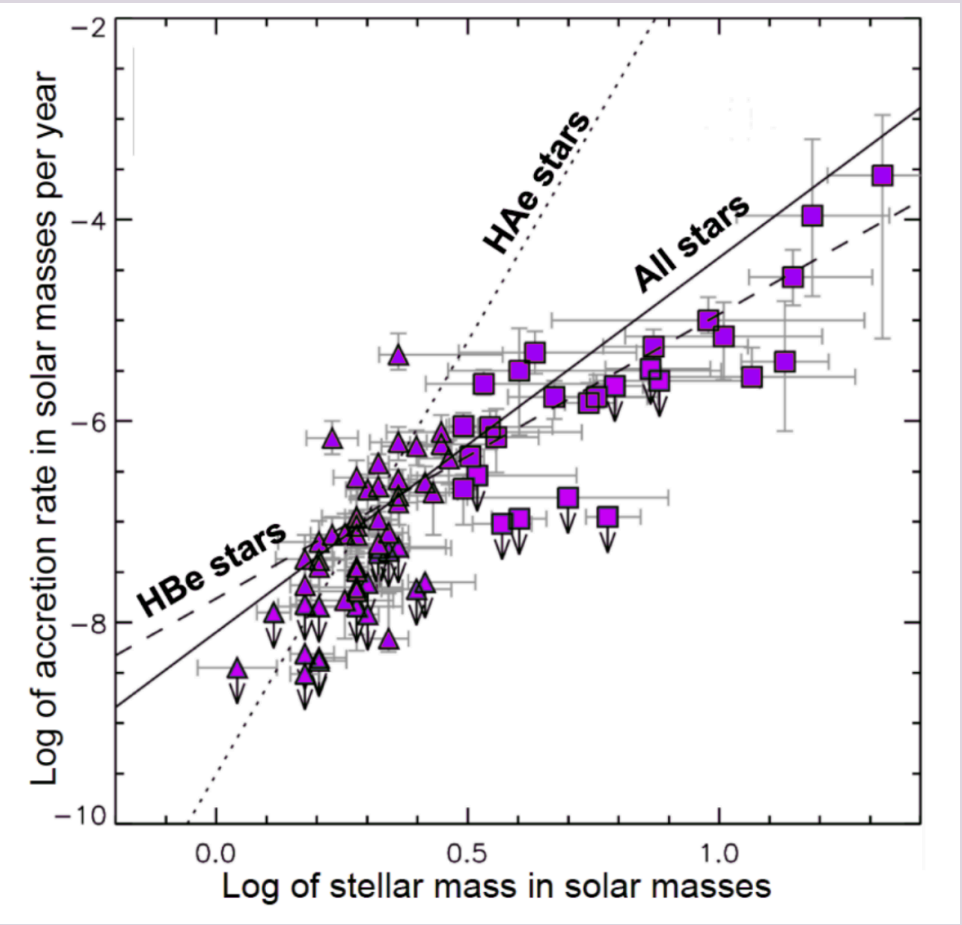

But: different slope Ae and Be objects

Break at around 3 solar masses

Occurs at similar mass as other such findings Vink+ 2002 (see also Muzerolle+ 2004, Grady+ 2010, Oudmaijer+ 2011, Cauley & Johns-Krull 2015, Scholler+ 2016)

Also, some early B-types have UV excesses that can not be reproduced with magnetospheric accretion

Need another mechanism.

Boundary layer accretion instead?

Mendigutia+ in prep; Fairlamb+ 2015

Fairlamb+ 2015, 2017

Stars could form in clusters: (Testi 1997)

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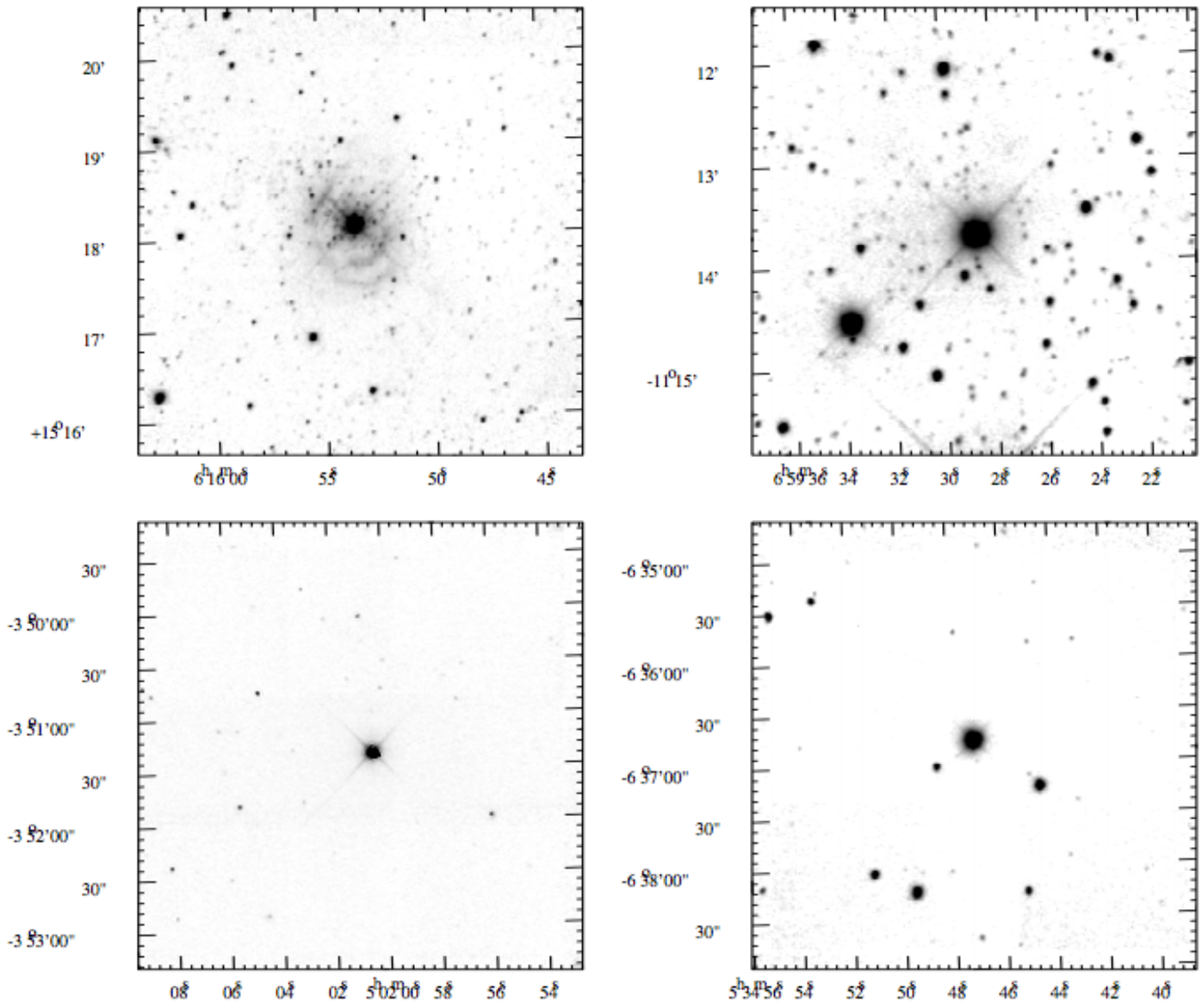

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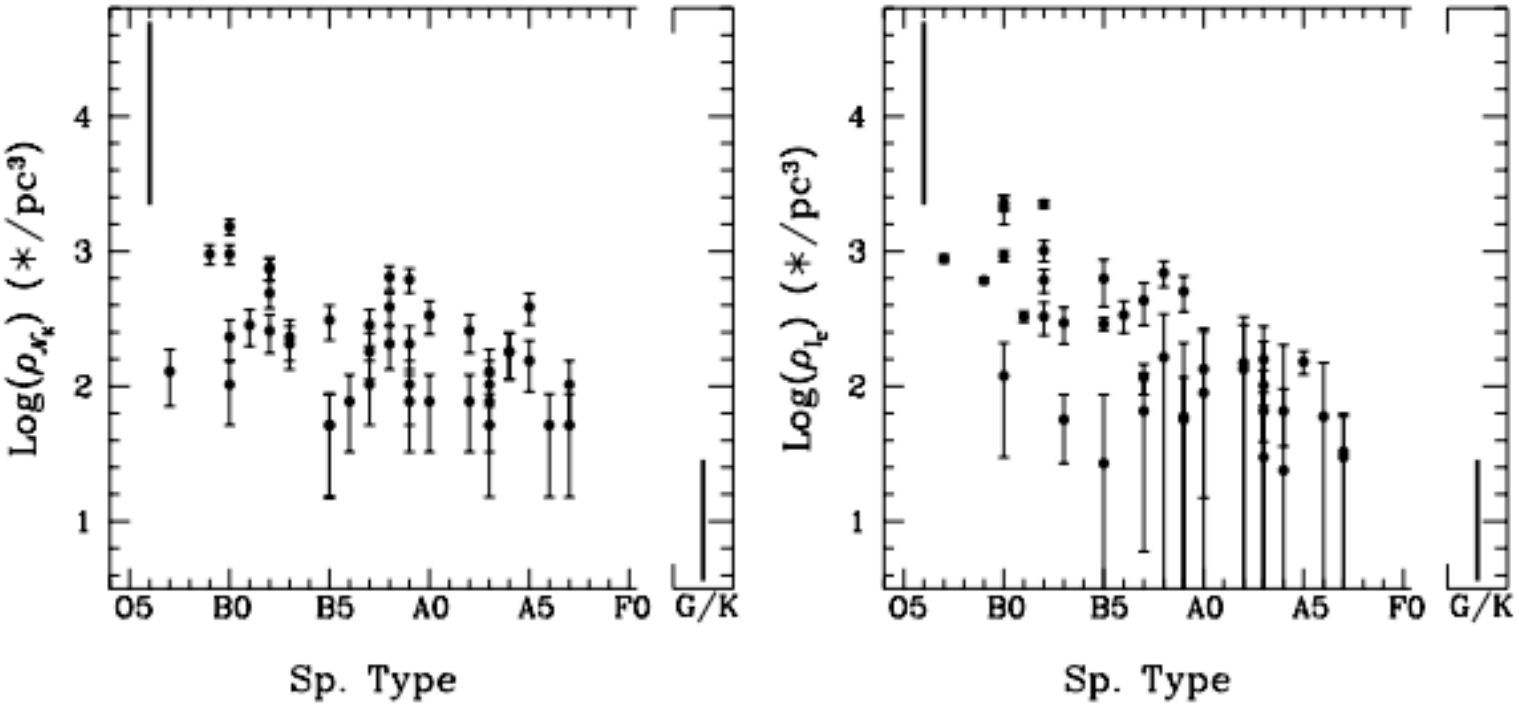

Fig. 7. Stellar volume densities derived from $\mathcal{N}_K$ (*left*) and from I_C (*right*) versus spectral type of the central star. Stars with $I_C < 0$ have been excluded. The heavy vertical line at O6 represents the range of stellar densities found in the Trapezium cluster, whereas that at G/K (not to scale) represents the densities of stellar groups in Taurus-Auriga.

Aim is to find more about the intermediate mass stars – no progress made since 1999!

MARIE CURIE ACTIONS

“Herbig Ae/Be” stars:

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STARRY

STARS THAT ‘R’ YOUNG

Aims:

1) Need more and better defined such objects
2) Find and characterize clusters around them

MARIE CURIE ACTIONS

The STARRY Project:

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- H2020 Innovative Training Network (ITN)
- European Industrial Doctorate (EID) Programme
- Twin Partner Site
- Two PhD Fellows
- Project Duration 48 Months
- 1 February 2016 – 31 January 2020

The HR diagram – GAIA DR2 results
Parallaxes + Total Fluxes ➔ Luminosities

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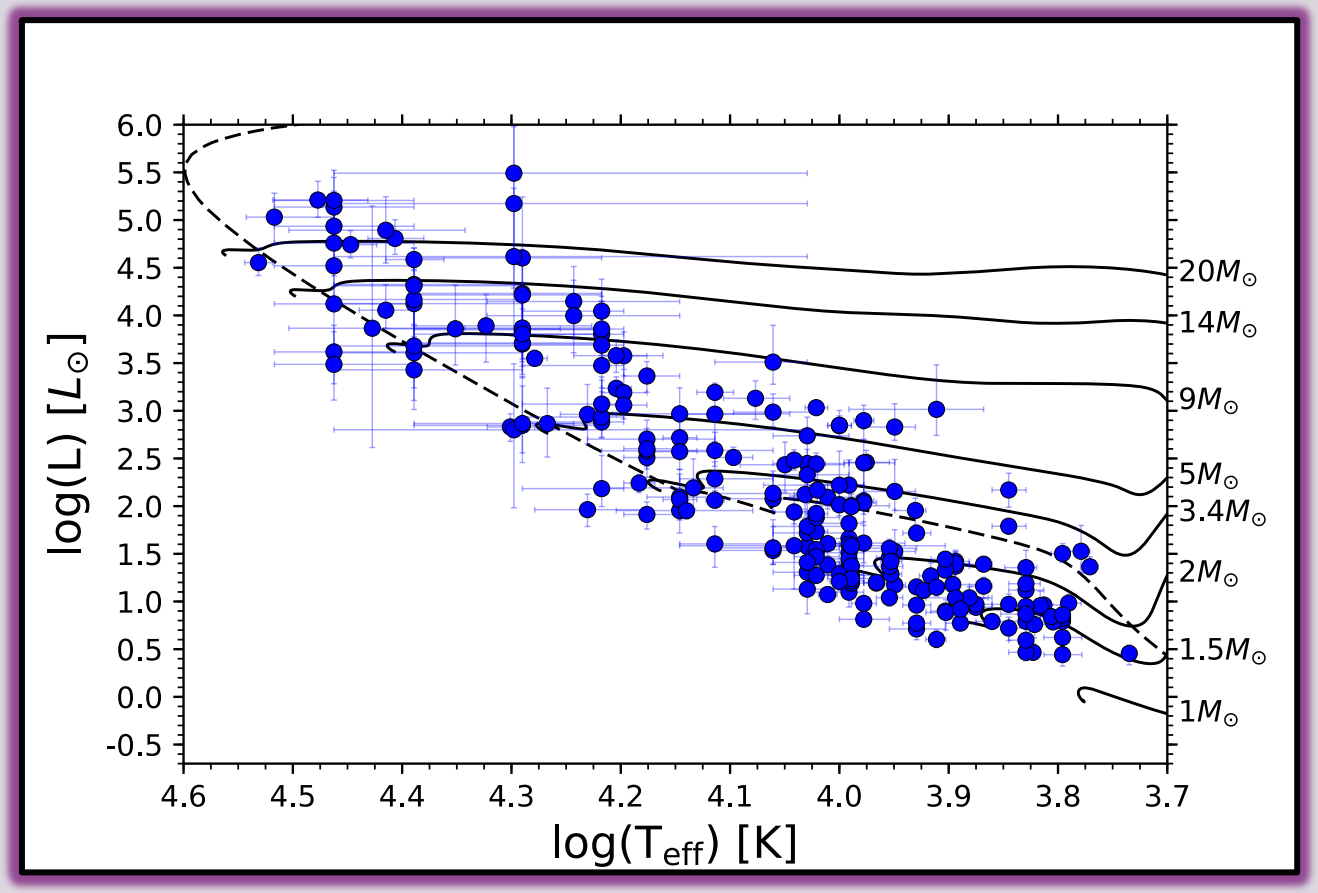
200+ objects could be placed on HR diagram.

PMS tracks ⟹ Masses

& Isochrones ⟹ Ages



Vioque+ 2018

Infrared excess vs. mass

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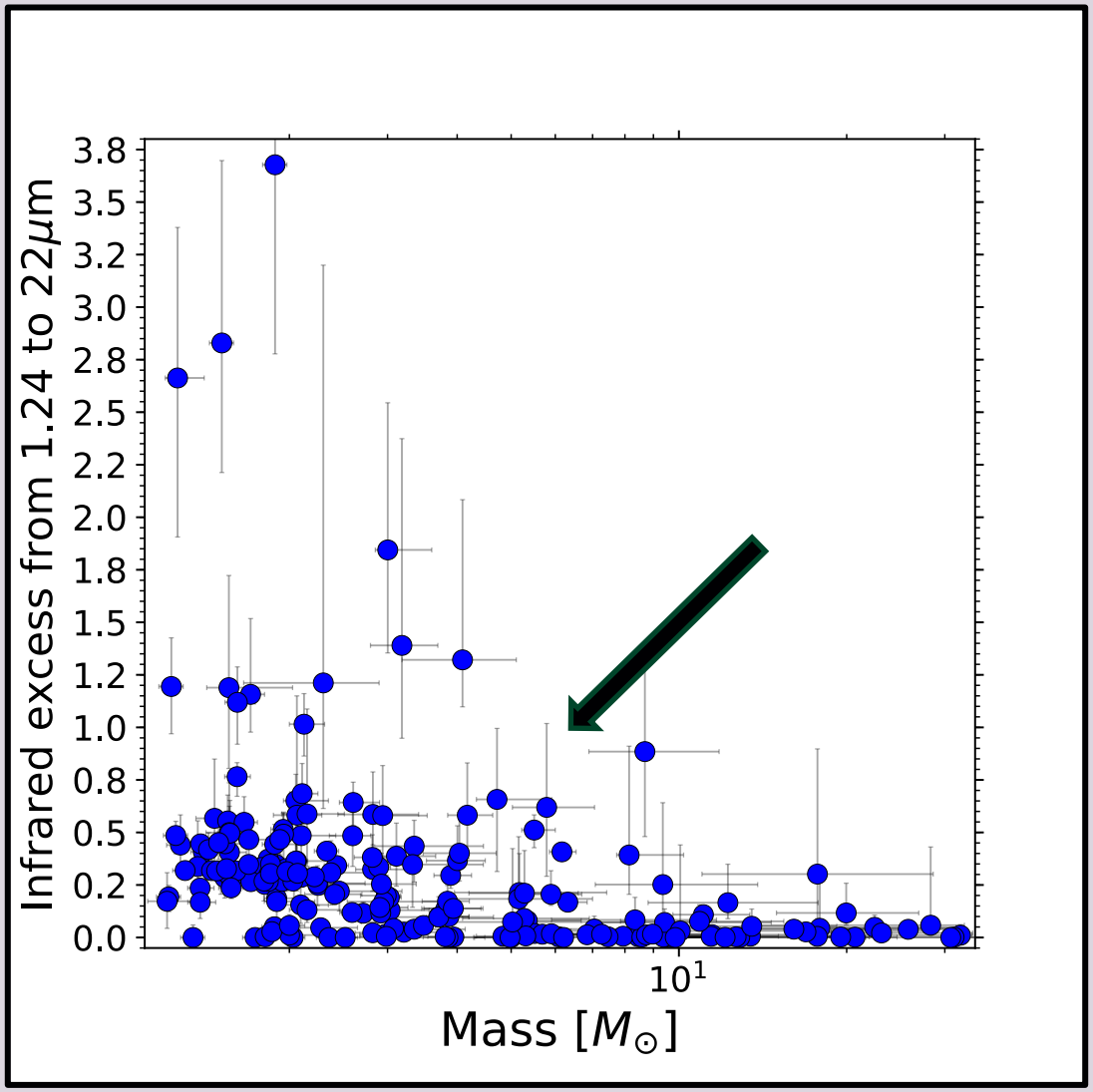

There appears a break at $7M_\odot$. Dusty environment different for early Herbig Be stars.

Related to more efficient dust evaporation at higher temperatures/ brightnesses.

See also Albi+ 2009, Gorti+ 2009

Variability from Gaia

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

Deason *et al.* 2017 variability amplitude:

$$A_i = \sqrt{N_{obs,i}}\, e(F_i)/F_i$$

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

V_i > 2 indicates >0.5mag variability

Variability derived from GAIA data vs. Mass

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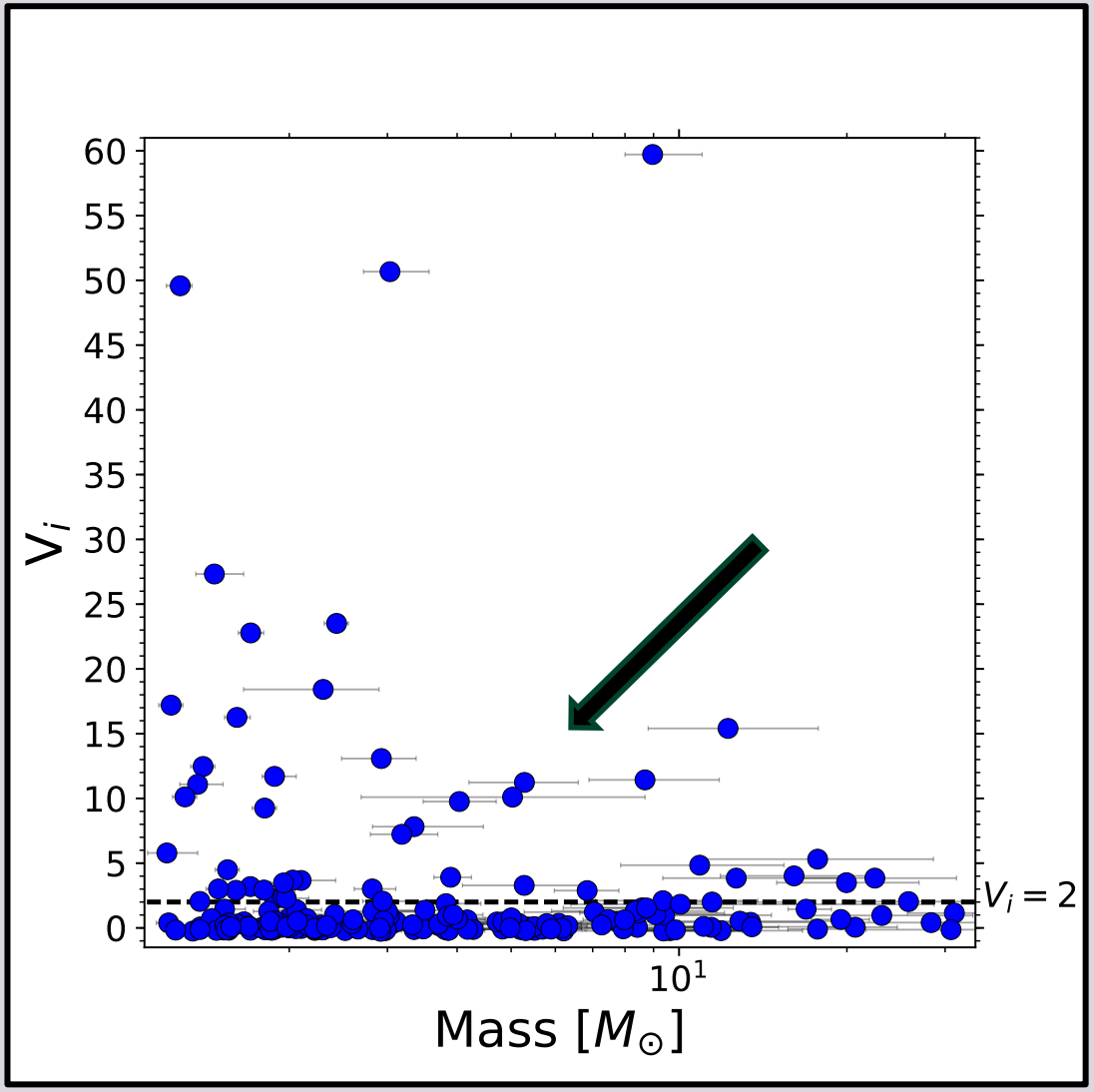

Same break at around 7 solar masses.

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

Variability vs. Infrared excess

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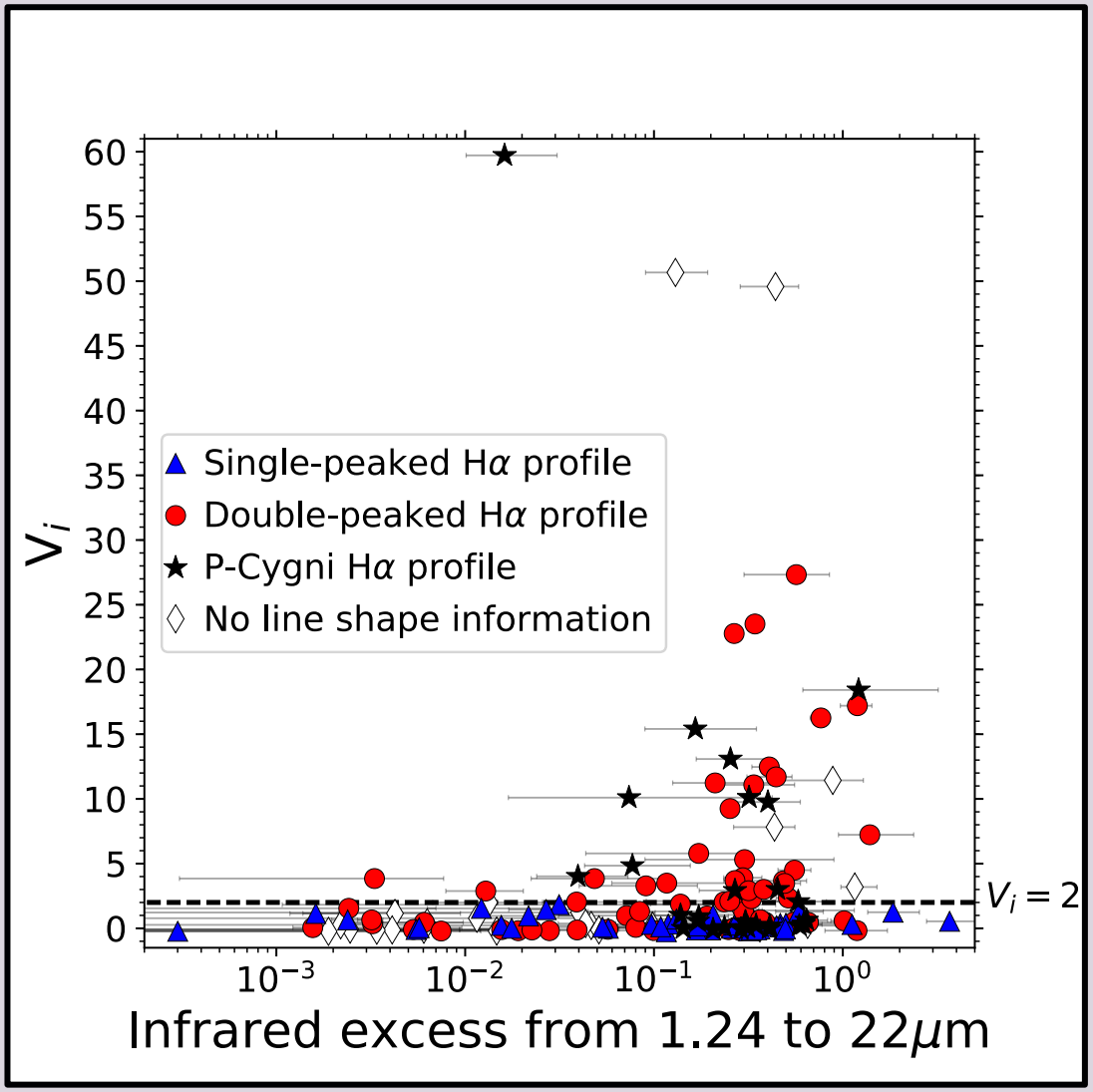
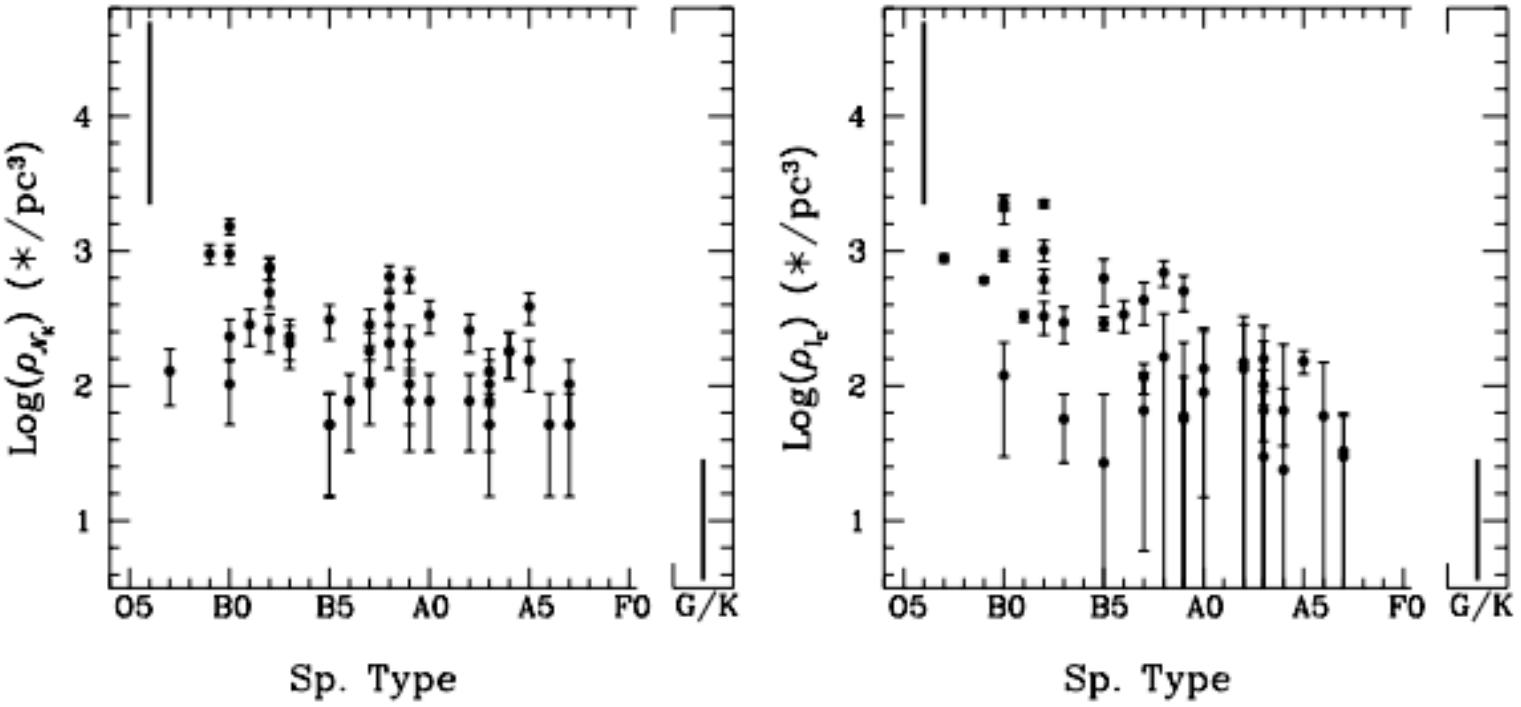


Most of the strongly variable Herbig Ae/Be stars show double-peaked Hα emission. None show a single-peaked line profile.

UXOR phenomenon

Grinin+ 1996, 2000

Ongoing: GAIA: Herbig Ae/Be stars as link between low and high mass stars – Clusters stats: Testi, Palla+ 97, 98, 99



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On-going

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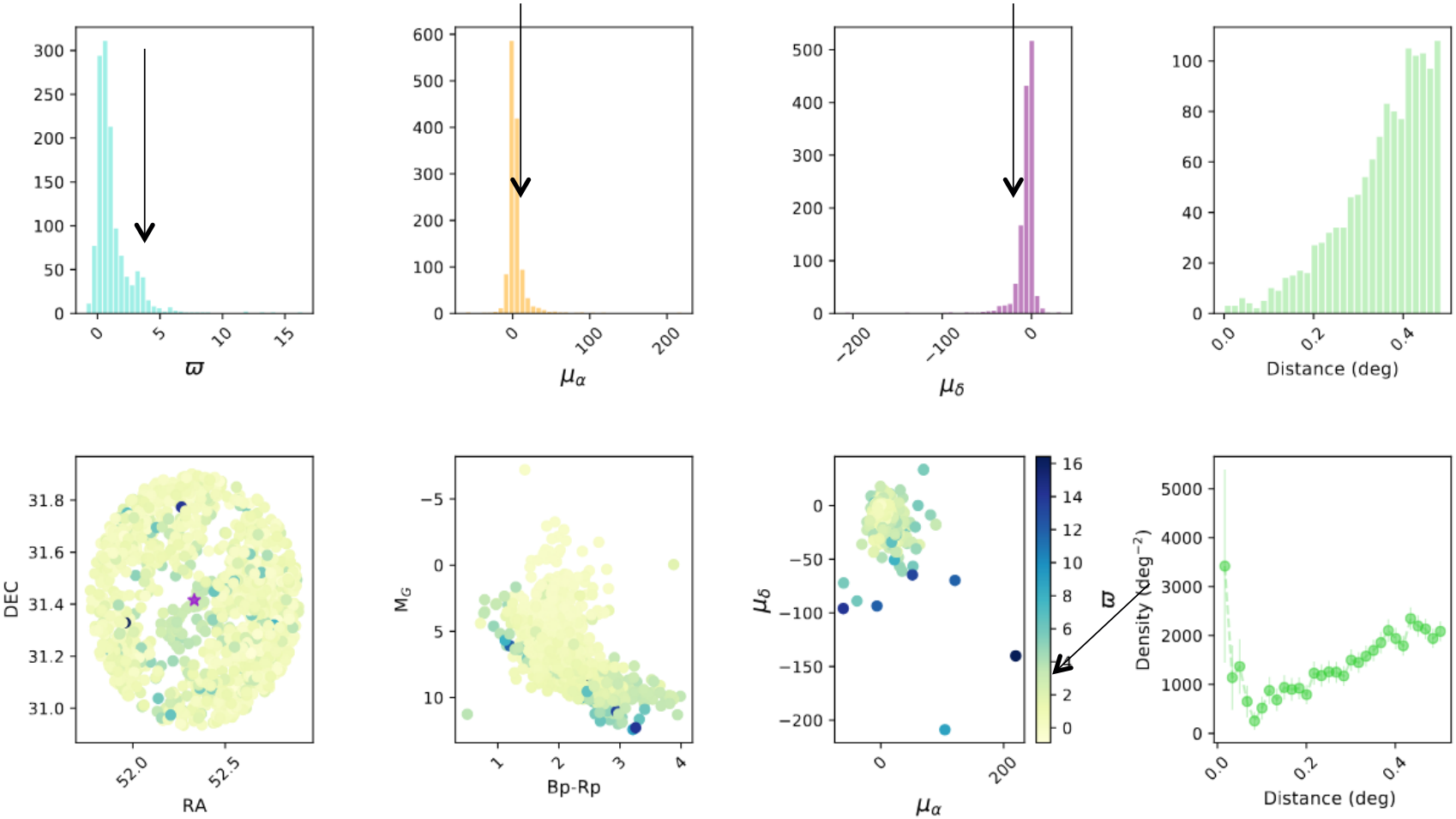
BD +30549



On-going

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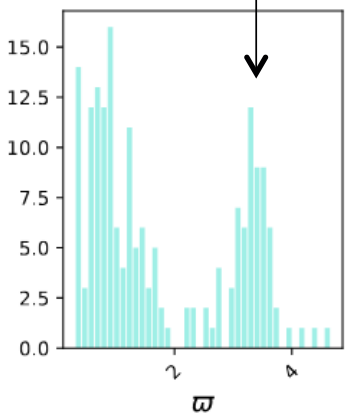

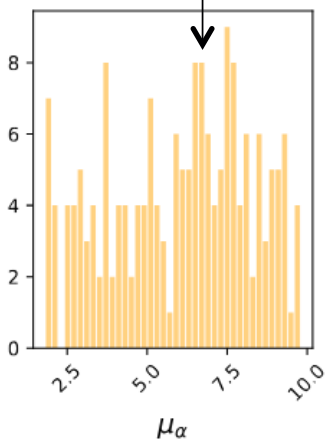

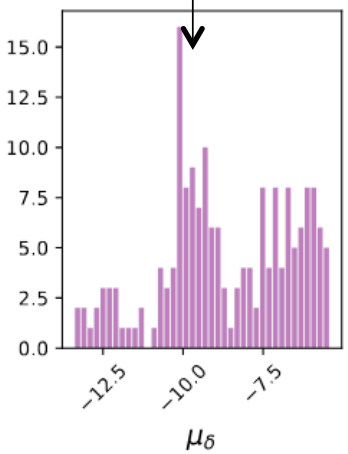

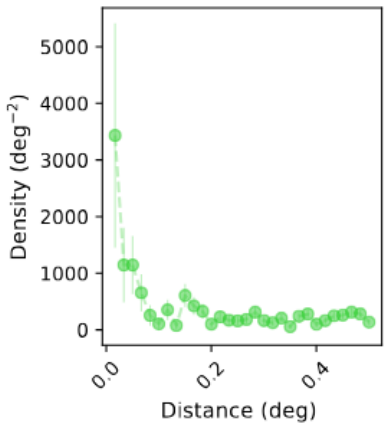

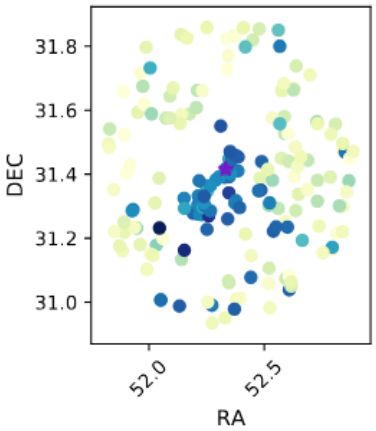

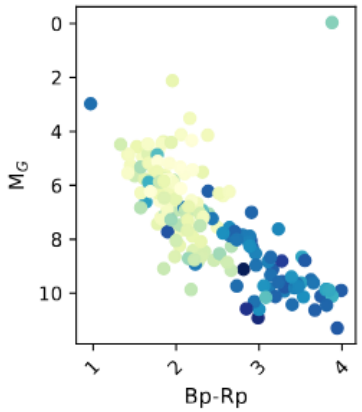

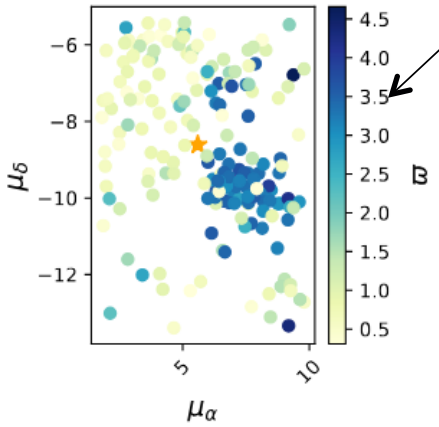

Object name = BD+30549

Final number of objects select = 182

PARALLAX value = 1.770 +/- 0.008 [mas]

PMRA value = 5.597 +/- 0.012 [mas/yr]

PMDEC value = -8.608 +/- 0.009 [mas/yr]

Known value of PARALLAX = 3.384 +/- 0.083 [mas]

Known value of PMRA = 6.822 +/- 0.109 [mas/yr]

Known value of PMDEC = -9.447 +/- 0.078 [mas/yr]

Future work: Finding new Herbig Ae/Be stars

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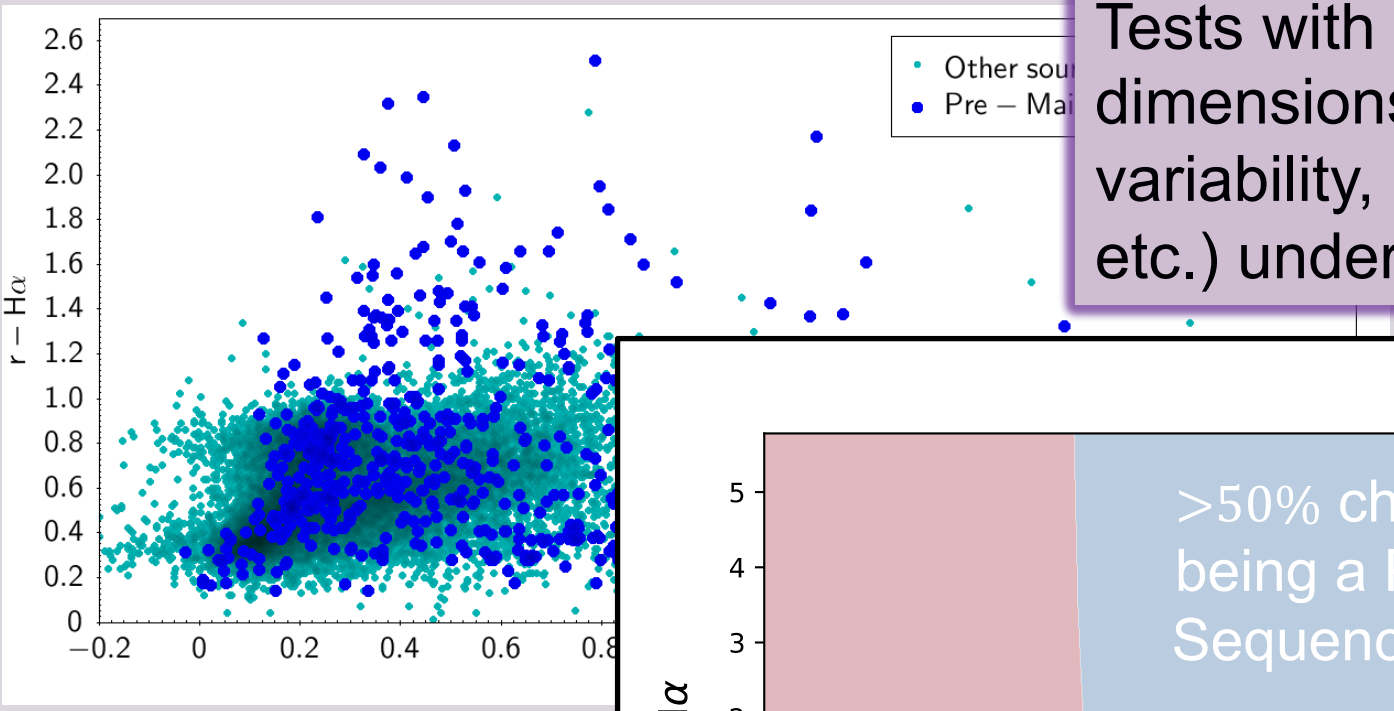
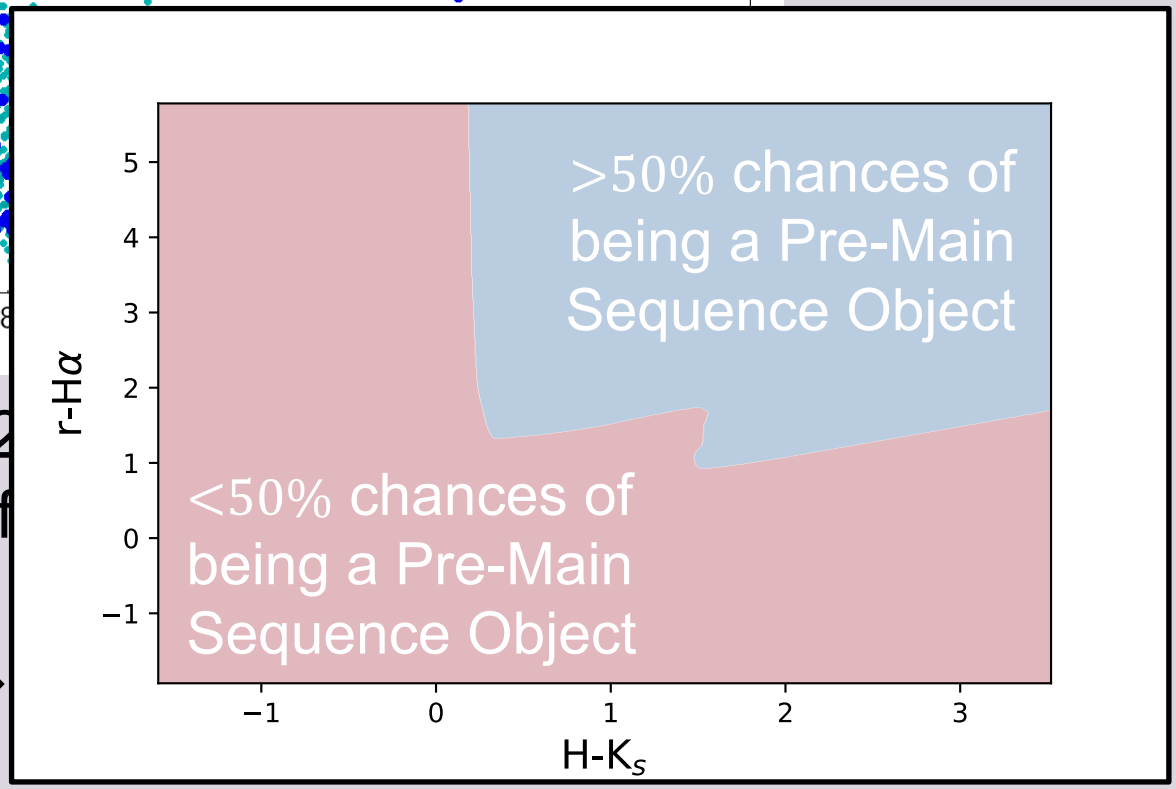


Tests with *N*-dimensions (colours, variability, HR diagram etc.) underway.

Neural Network: 2
parameter space af
training



Conclusions

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- Herbig Ae/Be stars bridge the gap between low and high mass young stars and cover the mass where change in accretion occurs.
- GAIA DR2 200+ objects in HR Diagram
- GAIA – dust tracing material further from star: change at 7 solar mass (photo-evaporation).
- Variability linked to edge-on disks – UXOR phenomenon

- Using HR diagrams, STARRY project will deliver new Herbig Ae/Be stars and their clusters
- STARRY will deliver “search and identify” tools and, if applicable, automatic cluster characterization.
- Great for all kinds of stars.

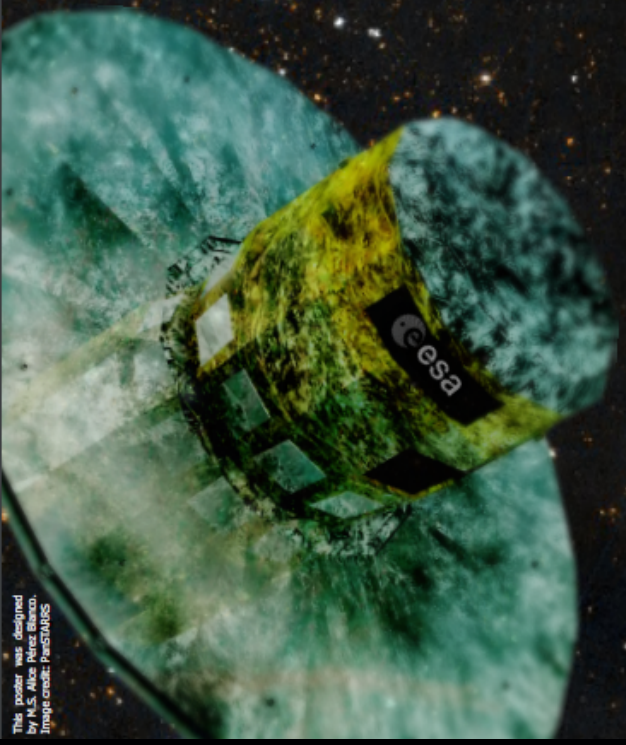
The STARRY project receives funding from the European Union’s Horizon 2020 Marie Skłodowska-Curie Actions (MSCA) programme under ITN_EID Grant Agreement No 676036.

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

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



This poster was designed by M.S. Alice Pérez Blanco. Image credit: ParaSTARRS

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Information

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