What happened before? The disks around the precursors of young Herbig Ae/Be stars.

UvA

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Introduction

A key questions is to understand how the formation and evolution of planetary systems depends on stellar mass. Can we connect the properties of planet-forming disks to those of mature planetary systems, and what role does the stellar mass play? When do the features seen in observations of planetary disks, spirals, gaps and cavities, form and what do they say about the planetary formation process?
Two main types of PMS stars have traditionally been observed to study the circumstellar disks and their evolution. The T-Tauri stars (spectral class F and later)and the Herbig Ae/Be stars (hereafter HAeBe, spectral class B and A). Overlapping in mass, the intermediate mass T Tauri (IMTT) stars with masses $M \geq 1.5 M_{\odot}$ will evolve through the Hertzsprung-Russel diagram (HR-diagram) to become HAeBe stars. The studies of circumstellar disks using HAeBe stars only, however, have introduced a bias in our view of planet formation and disk dissipation in this mass range. In order to have a full observational view of disk evolution and planet formation for intermediate mass stars, samples must be constructed that contain both HAeBe stars and their precursors, the IMTT stars.

Approach

Literature optical photometry (0.4-1.25μm) and distances determined from *Gaia* DR2 parallax measurements was used together with Kurucz stellar model spectra to place the stars in a HR-diagram (figure 1). With Siess et al.[1] pre-main sequence evolutionary tracks we identify intermediate mass T-Tauri stars from literature and derive masses and ages.

Final Sample

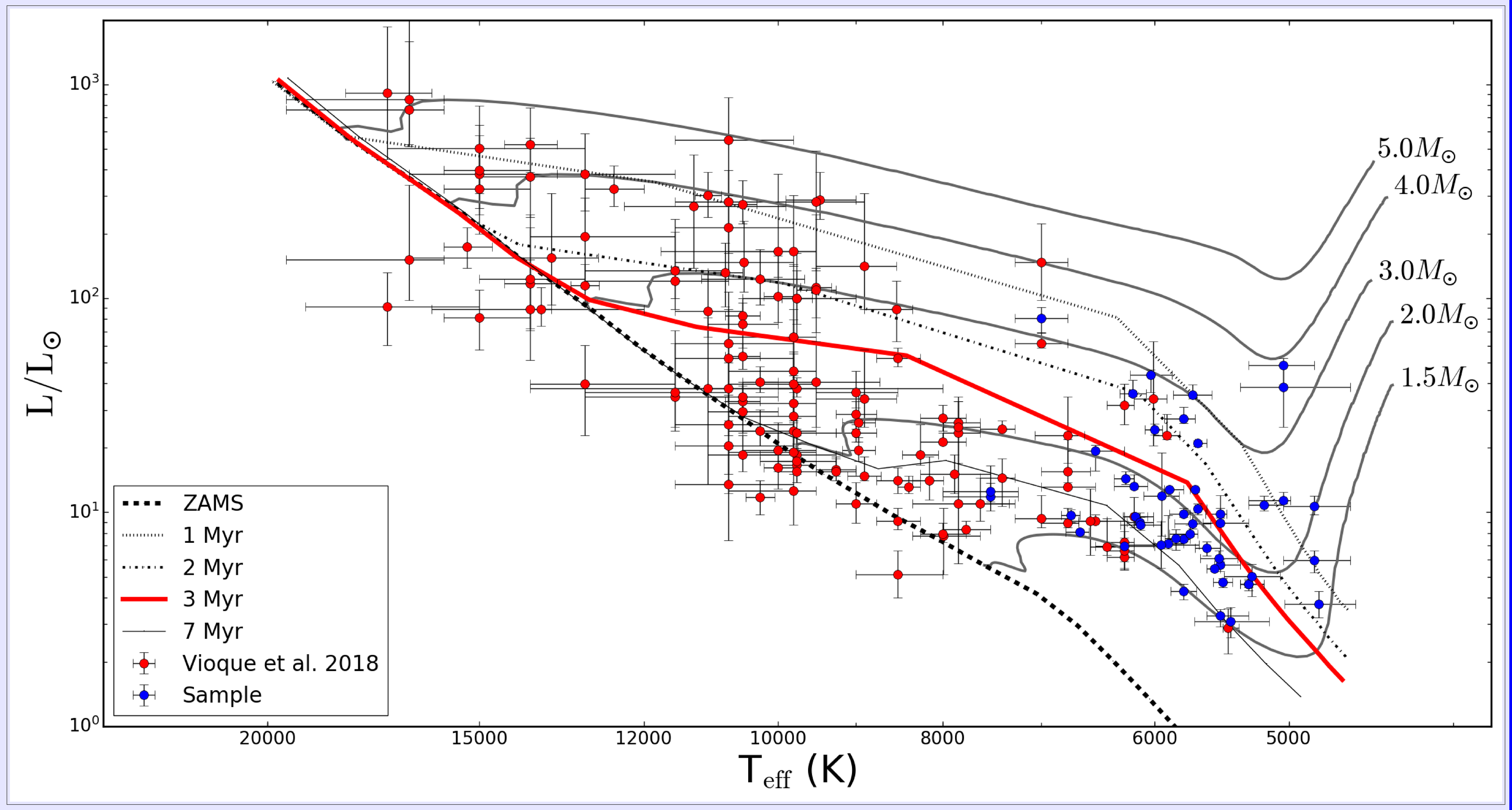

Figure 1:This HR-diagram shows the IMTT stars sample (blue) and the HAeBe sample from Vioque et al. [2] (red) that lies within the same mass range as the IMTT stars. Siess et al. pre-main sequence evolutionary tracks [1] (grey-solid). The isochrones shown are for 1 Myr (dotted), 2 Myr (dash-dotted), 3 Myr (red-solid) and for 7 Myr (black-solid) and the ZAMS (thick-dashed) is defined by the location when the nuclear luminosity provides 99% of the total stellar luminosity.

Disk properties

Spitzer spectra was used to classify the disks around the IMTT stars into Meeus Group I and Group II disks based on their [$F_{30}/F_{13.5}$] spectral index. The 10μm silicate dust grain emission is examined (figure 2) and emission from Polycyclic Aromatic Hydrocarbons (PAH) identified. From this a qualitative picture of the disks around the intermediate mass T-Tauri stars is built and compared with available spatially resolved images at infrared and at sub-millimeter wavelengths to confirm the classification.

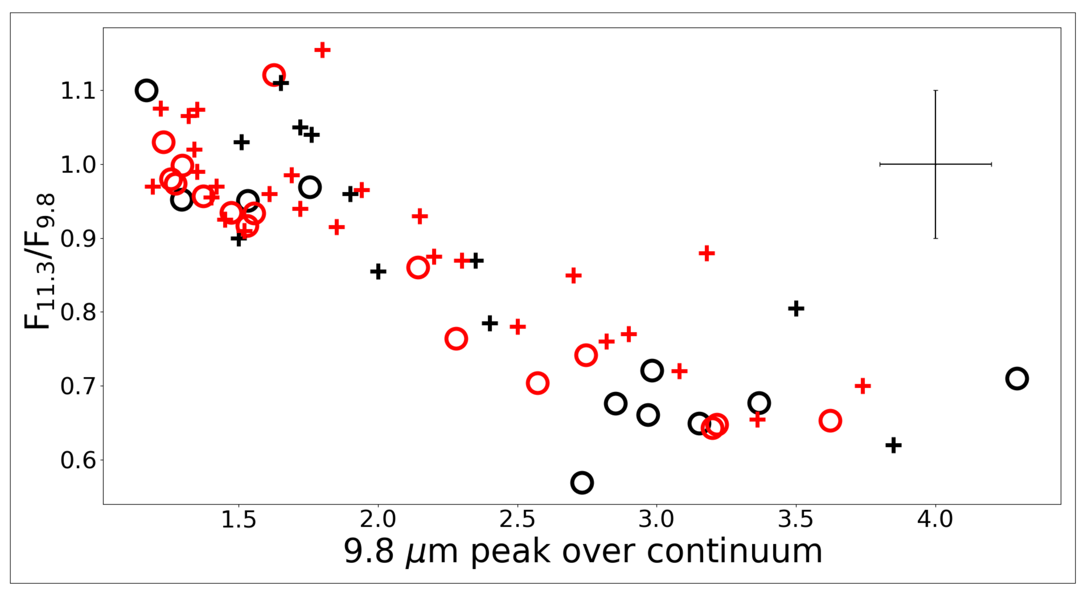

Figure 2:The degree of processing for the silicate grains in the disks around the IMTT star sample (open circles) and for the HAeBe sample from Juhász et al. [3] (crosses). Black are Group I disks and red are Group II disks. Smaller grains leads to a high peak over continuum intensity and a low [$F_{11.3}/F_{9.8}$] ratio. As grains grow the [$F_{11.3}/F_{9.8}$] ratio increases and the peak over continuum intensity weakens.

Result

This resulted in 49 intermediate mass T-Tauri stars with infrared excess. The identified disks are similar to the older HAeBe stars in disk geometries and silicate dust grain population. Spatially resolved images at infra-red and sub-mm wavelengths suggest gaps and spirals are also present around the younger precursors to the HAeBe stars.

Conclusion

Comparing the time scale of stellar evolution towards the main-sequence and current models of protoplanetary disk evolution the similarity between IMTT stars and HAeBe stars seems to indicate that the Meeus Group I and Group II are disconnected and represent two different evolutionary paths.

References

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Contact Information and link to paper

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