# Dust Grain Sizes In Herschel-Resolved Debris Discs


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## Introduction

Collisional models of debris discs robustly predict that the minimum size of their dust grains, $s_{min}$, should be set by stellar radiation pressure. Under reasonable assumptions about the composition and density of dust, the blowout radius $s_{blow}$ is expected to vary from several tenths of a micron for G-type stars to several microns for A-type stars. For most of the discs, $s_{min}$ is predicted to be a few times $s_{blow}$, and the size distribution index $q$ to lie approximately between 3 and 4. At first glance, this seems to be supported by observations. Typical grain sizes inferred from thermal emission and scattered light images of many individual discs lie at a few microns. Therefore we would expect a nearly constant $s_{min}/s_{blow}$ ratio for all discs. To check this, we used a uniform sample of 22 well resolved debris discs taken from various Herschel programmes. Fixing the disc radii, $R_{disc}$, to the extent inferred from the resolved images, we performed SED modelling to find best fit $s_{min}$ and $q$ values for each target.

## Target selection and data acquisition

- Targets:
  - 22 discs around AFGKM stars with ages of 100 Myr-10 Gyr, well resolved in several Herschel programmes were used.
  - $R_{disc}$ was derived from FWHM of resolved images at 100 µm:
    - Model discs at a distance of 20 pc with different radii were assumed.
    - Their extended emission was convolved with the PSF and the stellar contribution was added.
    - 2D Gaussian profiles were fitted to the major and minor axes of synthetic images.
    - The resulting FWHMs were compared to FWHMs of the Gaussian profiles fitted to resolved images.
- Data:
  - Photometric data were collected from various catalogues and surveys such as 2MASS, WISE, AKARI, Spitzer, SCUBA.
  - Herschel data were taken from papers cited or reduced by us.
  - The stellar photospheres were calculated with a (Hauschildt et al. 1999) model.
  - SED fitting was done with an extended version of SEDUCE (Müller et al. 2010).

## Disc radii

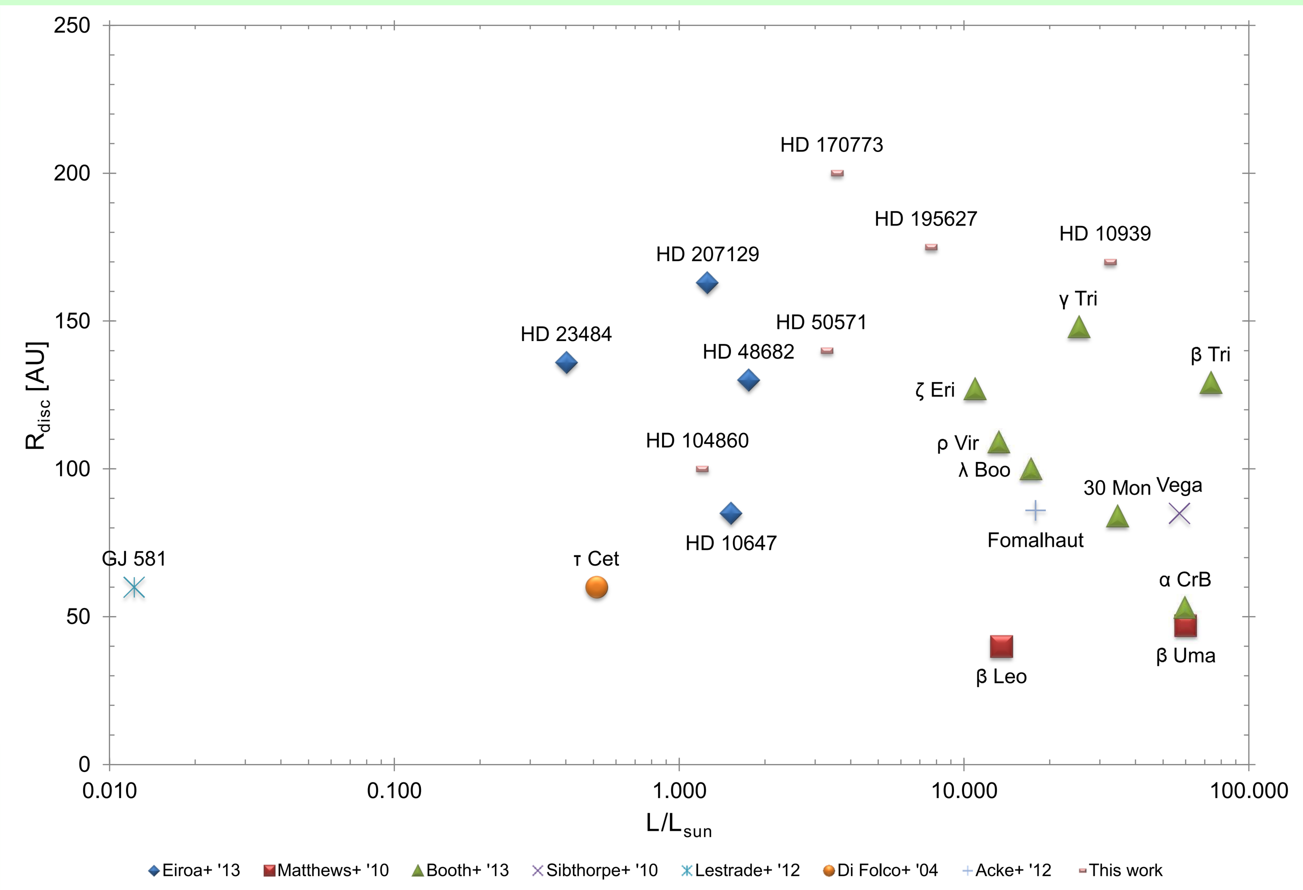


Figure 1: Disc radii for different stellar luminosities.

Disc radii do not seem to correlate with stellar luminosity.
This result is roughly consistent with Eiroa et al. (2013).

## Dust temperatures

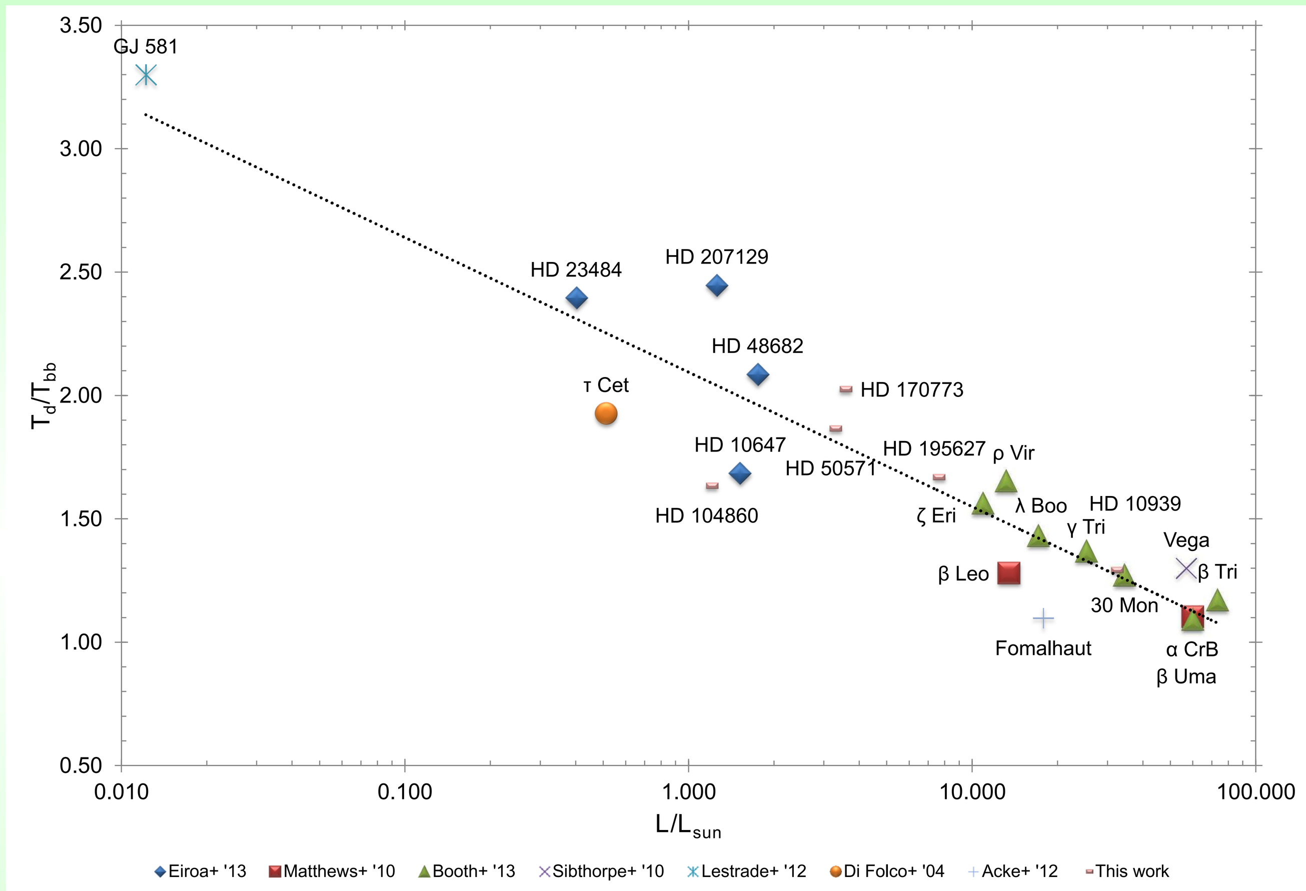


Figure 2: Dust temperature to black body temperature ratio for different stellar luminosities.

The dust to black body temperature ratio decreases with increasing luminosity.
This result is consistent with Booth et al. (2013).

## Minimum grain size

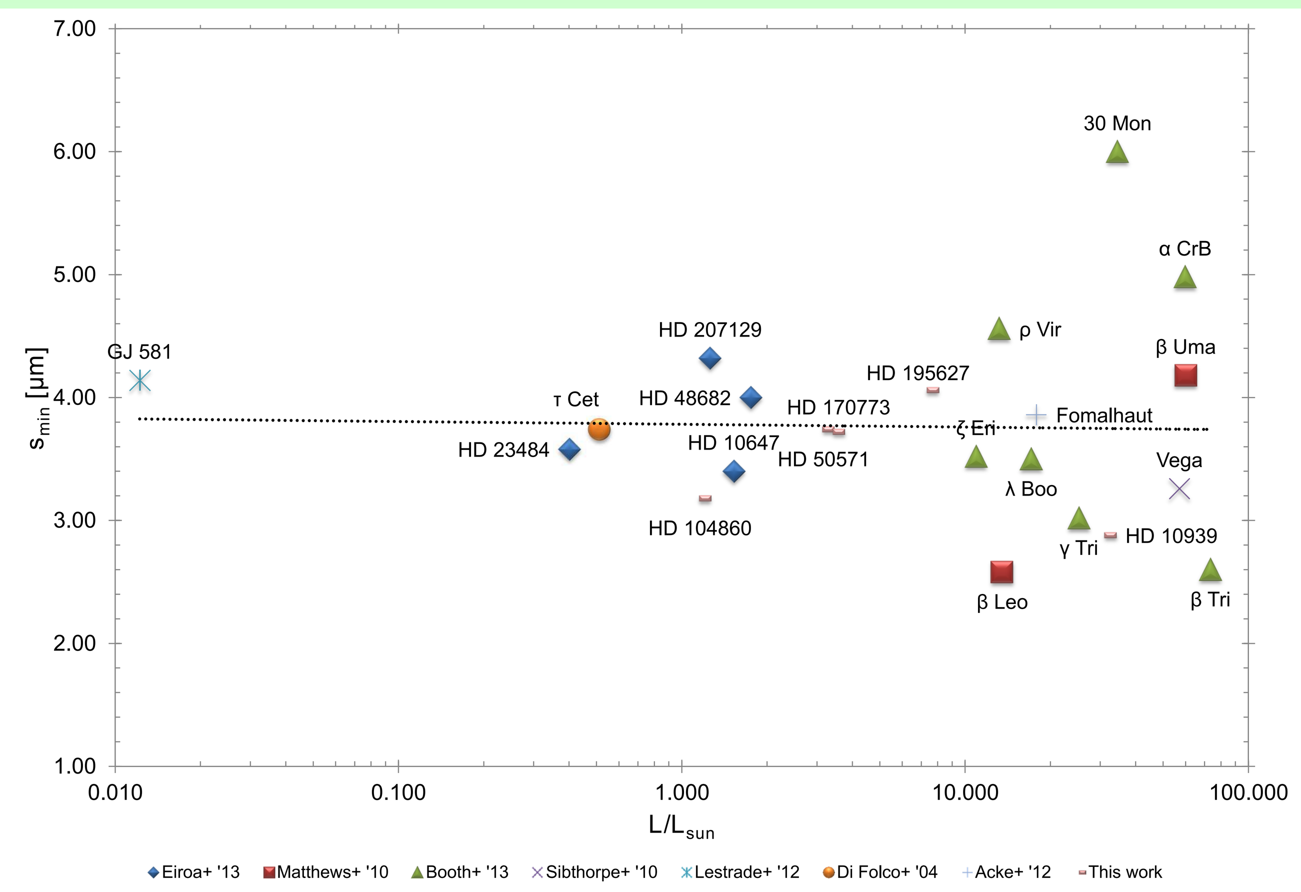


Figure 3: Minimum grain size $s_{min}$ for different stellar luminosities.

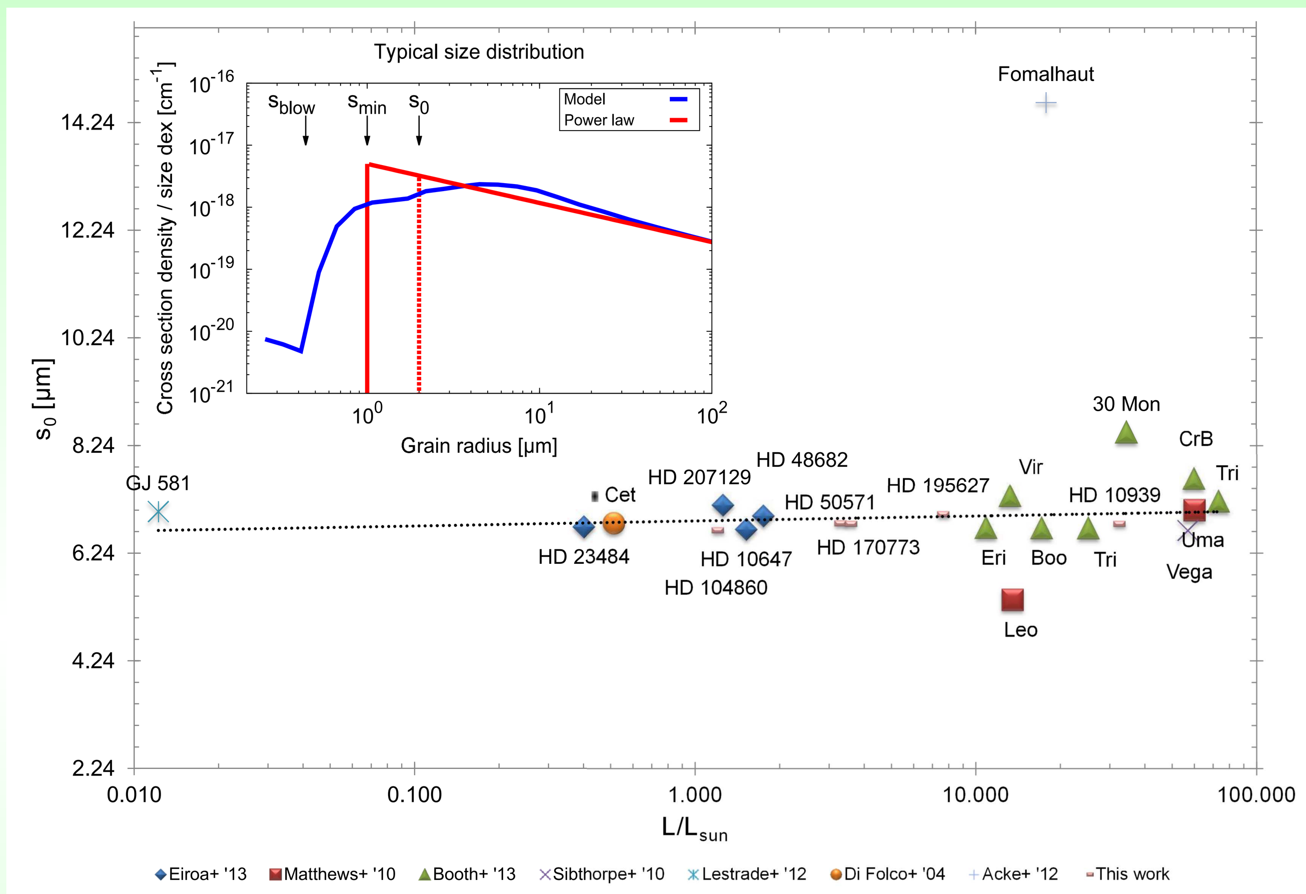


Figure 4: Effective grain size $s_0$ for different stellar luminosities.

- $s_{min}$ lies between 2.5 µm and 6 µm for all spectral types 4 µm ± 2 µm.
- Dispersion of $s_{min}$ increases with increasing luminosity. Around high luminosity stars, $s_0$ cannot be calculated as accurately as for low luminosities. At higher stellar luminosities, dust grains start to behave like black bodies already at smaller sizes.
- The size distribution index $q$ varies from one disc to another. Hence we replaced the disc of grains with a size distribution by a cross section-equivalent disc of equal-sized grains with radius $s_0 = s_{min} \cdot \sqrt{(q-1)/(q-3)}$.
- $s_0$ is independent of the stellar luminosity and lies at 7 µm ± 1 µm.

## Conclusions

- No significant correlation between $R_{disc}$ and stellar luminosity could be found.
- The dust to black body temperature ratio decreases with increasing luminosity.
- The minimum dust grain size $s_{min}$ is independent of stellar luminosity. Its determination is less accurate at higher luminosities.
- We find that $s_{min}/s_{blow}$ ratio is not constant. **Instead, $s_{min}$ is constant.** This might indicate systematic differences in disc properties with the stellar type, such as the dust in chemical composition or disc stirring level.

## References


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