# The Herschel Key Programme DUNES – Sample selection and SED modelling

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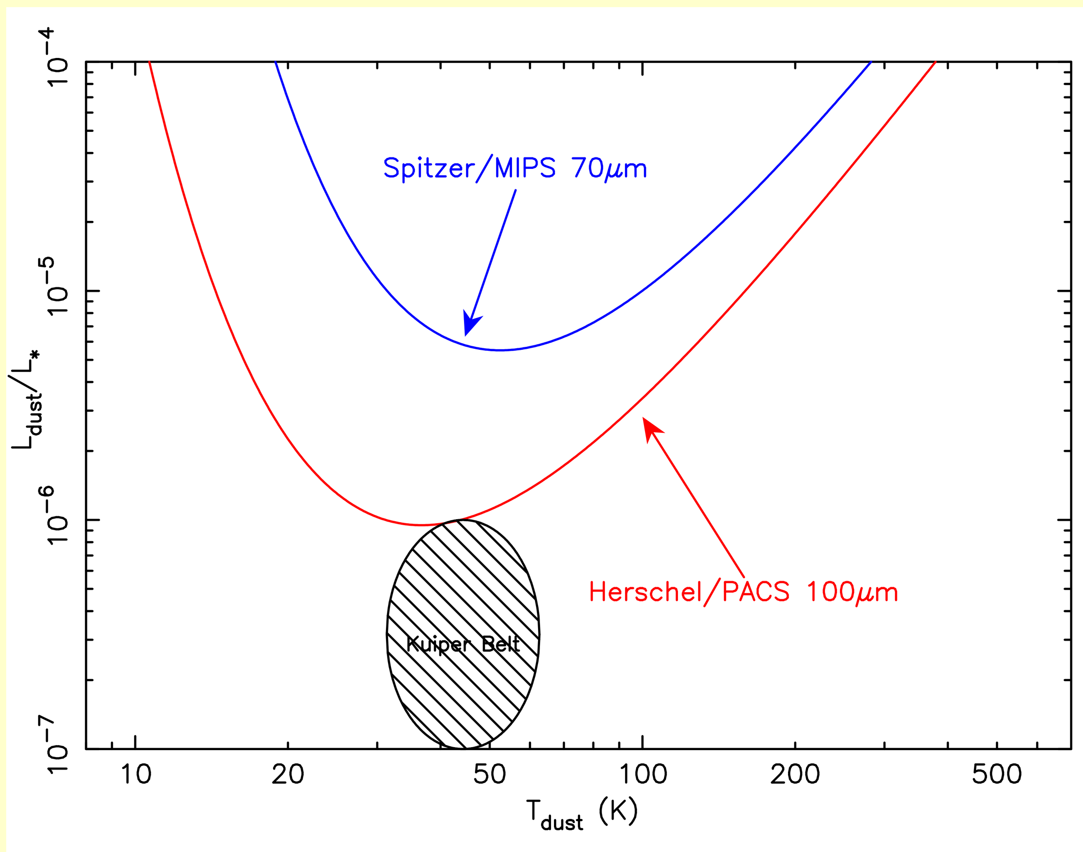
Due to its wavelength coverage and sensitivity, the Herschel Space Observatory will be the ideal facility to search and study debris disks similar to the Edgeworth-Kuiper Belt in the Solar System.

The Open Time Key Programme DUNES (*DUst around NEarby Stars*) will search for extrasolar EKB analogues. The goal is to determine the fraction of faint, cold debris disks around a statistical sample of nearby FGK main-sequence stars as a proxy of the incidence of planetary systems (see also Poster no. 121 by C. Eiroa et al.).

## Sample selection

We have defined a volume-limited sample by selecting from the Hipparcos catalogue FGK main-sequence stars within 25 pc. Targets were chosen on the basis of the expected signal-to-noise ratio (SNR>5) of the stellar photosphere at 100 $\mu$m, the most suitable Herschel photometer band for the detection of EKB analogues.




The photospheric fluxes have been estimated with Kurucz photospheric models normalized to optical/near-IR photometry. The noise budget comprises the sky background fluctuation (source confusion) and the instrument noise levels. At 100 $\mu$m the typical (all-sky average) confusion noise level is $\sim$ 0.6 mJy, but at low galactic latitudes ($|b| \lesssim 10°$) it can be up to two orders of magnitude higher. For computing the expected signal-to-noise ratios of the stellar photosphere, we assumed that the optimal Direct Mode will be used for reading out the PACS detectors.

## Sample

The final stellar sample comprises 133 solar-type stars, thereof 27 F, 52 G, and 54 K stars. About one fifth of the targets show infrared excess emission, e. g. from MIPS/70 $\mu$m measurements. Around 20 stars are known from radial-velocity measurements to harbour at least one planets.

## SED modelling

We developed an analysis package aimed at modelling the optically thin emission of circumstellar debris disks. The program consists of two parts: (1) A multi-parameter debris disk model to compute spectral energy distributions called Debris Disk Radiative Transfer Simulator (Wolf & Hillenbrandt 2003). (2) A minimization routine to find the best-fit solution to observational data, as provided by Herschel or other infrared/(sub)mm facilities. Fitting an observed SED allows to derive important disk parameters, e.g. the inner radius of the disk, the characteristic dust grain size, or the total mass of emitting dust.

The WWW-version of the Debris Disk Radiative Transfer Simulator (DDS) is available at `www1.astrophysik.uni-kiel.de/dds/`.

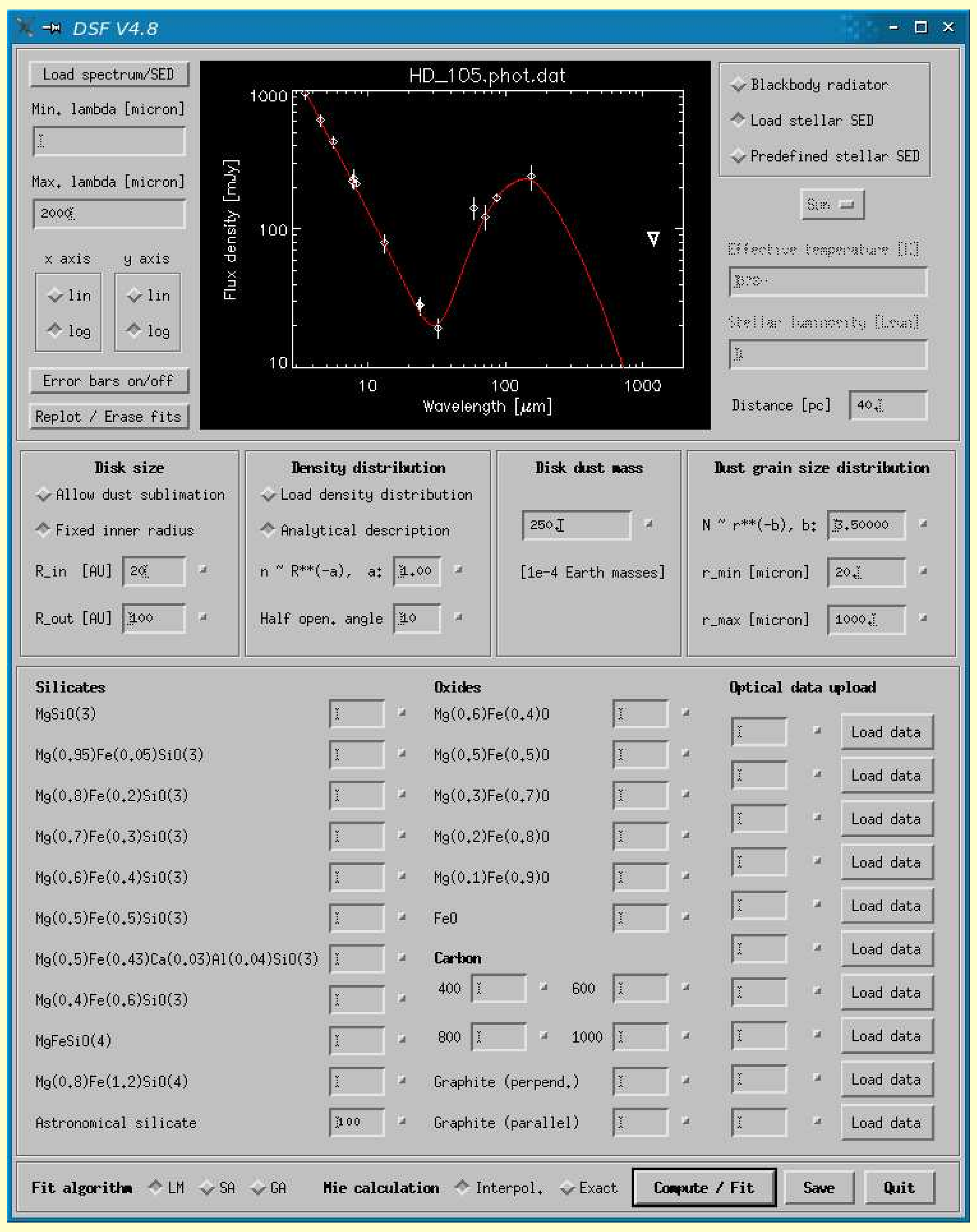
## Model parameters

The spectral energy distribution of a debris disk depends on the central star's radiative input, the extent and density distribution of the disk, and the size and optical parameters of the dust particles. Possible fit parameters are:

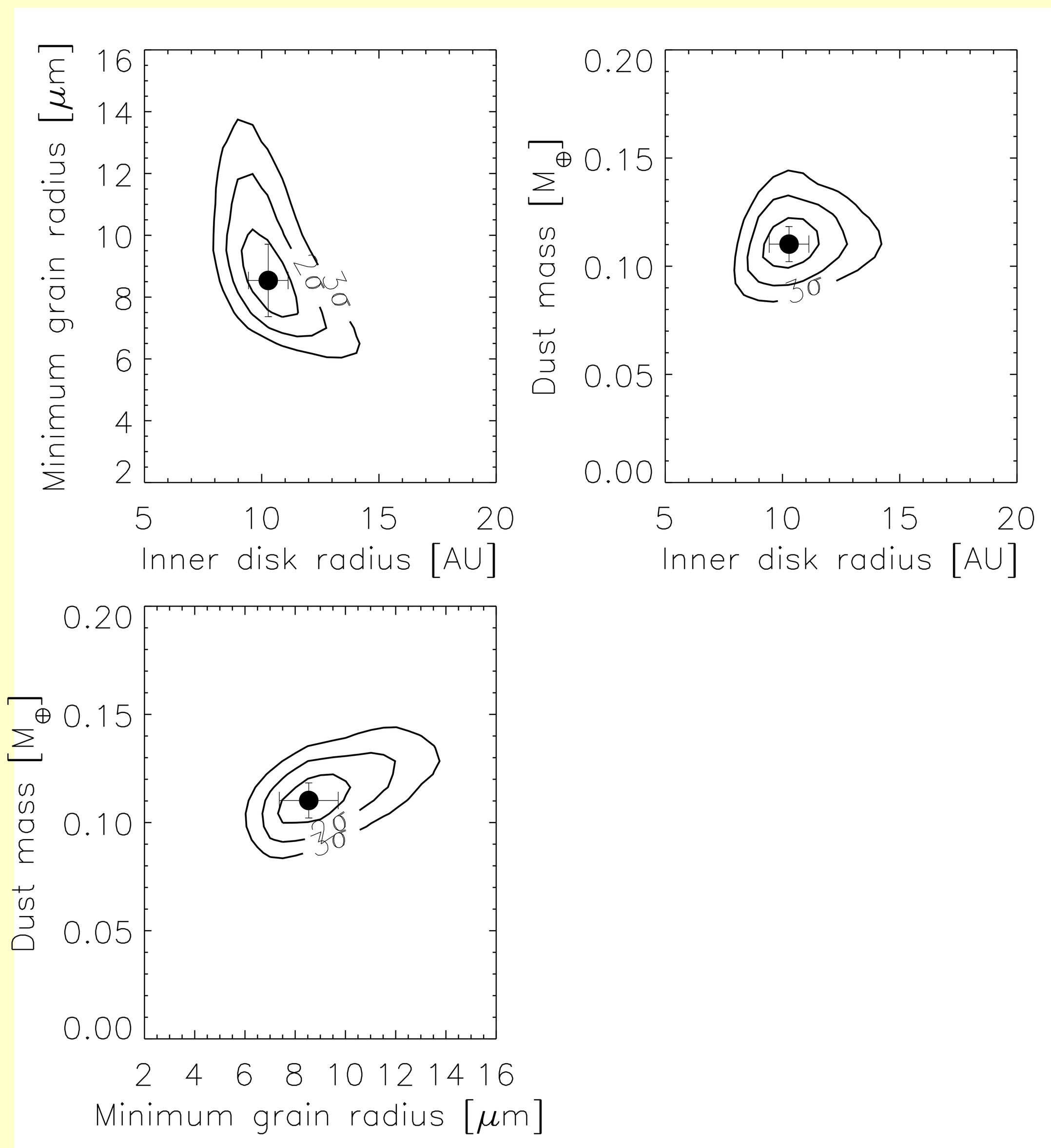
- **Central star/heating source** — Specified by a model of the stellar photosphere, e. g. Kurucz or NextGen photospheric model, or a blackbody radiator ($L_\star$, $T_{\rm eff}$).
- **Dust density distribution** — Defined by the inner/outer disk radii and the power-law index of the density profile. The density distribution can also be prescribed by inner disk radius and the width of the dust belt.
- **Grain size distribution** — Specified by minimum/maximum particle radii and the power-law exponent of the size distribution.
- **Disk mass** — The total mass of dust particles of in a dust size range. Since the disk is optically thin, the dust re-emission scales linearly with the disk mass.
- **Dust mineralogy** — Dust species of different chemical/mineralogical composition (silicates, oxides, carbon) can be used.

## Fitting tool

To find the parameter values of the model that matches an observed spectral energy distribution best, we are using the Levenberg-Marquardt algorithm for local $\chi^2$ minimization. An IDL graphical user interface controls the fit procedure.




After the minimum $\chi^2$ has been found, the set of best-fit model parameters, their uncertainties, and confidence intervals are plotted.




Best-fit parameters and confidence regions for the G2V star HD 107146 (Roccatagliatta et al. 2008).

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See also
`www.mpia-hd.mpg.de/DUNES/`