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Temperature and thermal emission of cosmic dust in the vicinity of the Sun, Vega and Fomalhaut

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/ INTRODUCTION

- Many stars are known to have debris disks and dust is distributed throughout these disks
- Cosmic dust around a star absorbs electromagnetic radiation and re-radiates at a longer wavelength, determined by its temperature.
- The dust emission contributes to the observed spectral energy distribution of the star
- Dust close to the Sun can possibly be measured with the ESA mission Solar Orbiter and NASA mission Parker Solar Probe (Fig.1)
- Observations suggest that there is a narrow ring of dust close to Vega and Fomalhaut

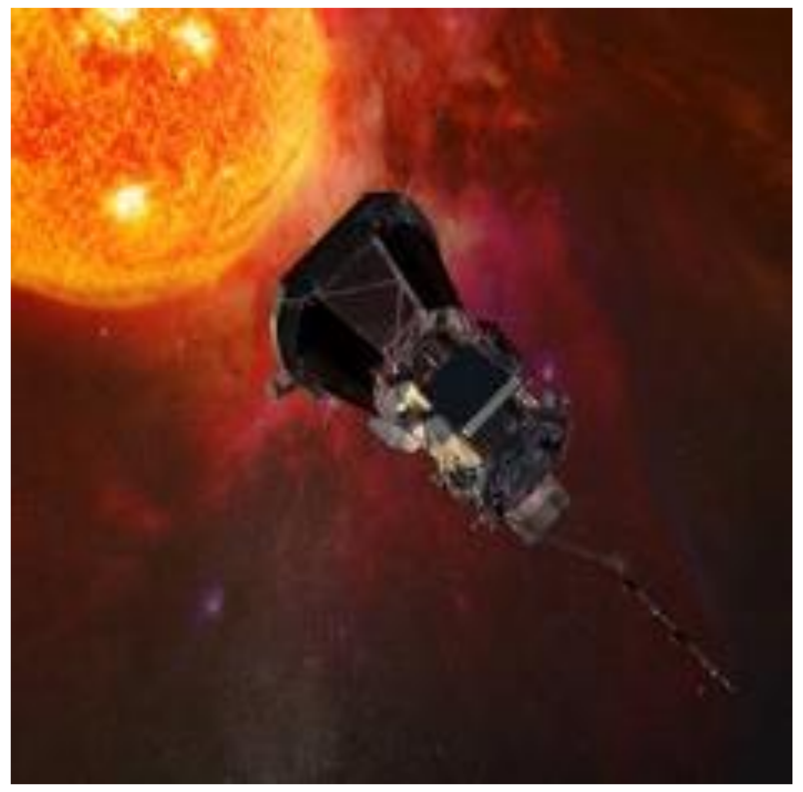

Figure 1: Artistic illustration of Parker Solar Probe to be launced in 2018 © NASA

- Size distribution and total dust mass used to compute total emission surface

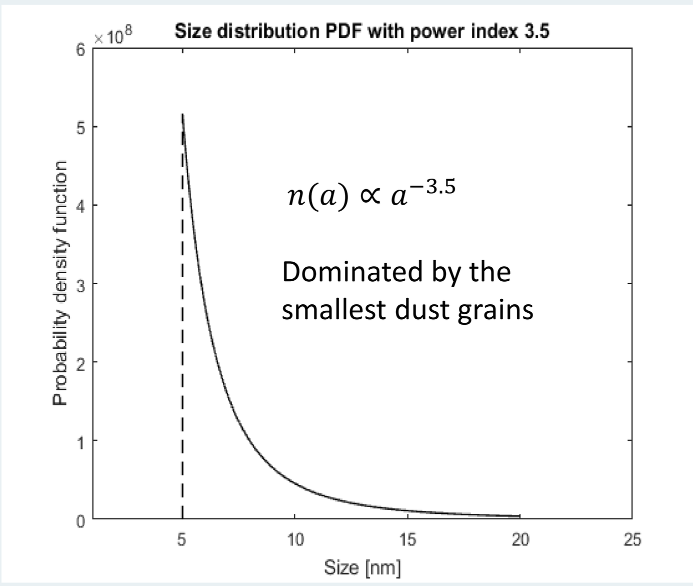

Figure 2: Power law size distribution

/ METHOD

- The thermal emission was computed by:

$$\Phi_{th}(\lambda) = \frac{1}{4\pi d^2}\int_{a_{min}}^{a_{max}} \pi B_\lambda(T_{dust}(a,r))4\pi a^2 n(a,r) Q_{abs}(\lambda, N(\lambda), a)\, da$$

d = distance between observer and star
r = distance between dust and star
$n(a, r)$ = size/density distribution
a = radius of dust grain
B_λ = Planck function

- Dust temperature calculated for thermal equilibrium:

$$\pi a^2 \left(\frac{R_{star}}{r}\right)^2 \int_0^\infty \pi B_\lambda(T_{star}) Q_{abs}(\lambda, N(\lambda), a)\, d\lambda = 4\pi a^2 \int_0^\infty \pi B_\lambda(T_{dust}) Q_{abs}(\lambda, N(\lambda), a)\, d\lambda$$

- Dust composed of amorphous carbon, astronomical silicate, ice or a mixed iron/magnesium oxide (MgO/FeO) with refractive indices $N(\lambda)$ from [4] and [5]
- Dust with sizes in the range of 5 to 20 nm in a size distribution (Fig.2) and with size 100 nm and 1 µm
- Absorption efficiencies Q_{abs} based on Mie scattering
- Assumed that the dust resides in a narrow ring from 0.18 to 0.2 AU around the star, a constraint set by [7]
- A ring around 1 AU was tested for comparison
- Spectral energy distribution will be compared to observations from [1] and [3] for Vega and [2] and [6] for Fomalhaut
- Derive the total mass of dust in units of Halley comets to adjust the absolute brightness of the spectral energy distribution

/ RESULTS

- The dust temperature with various compositions and sizes is different from black body
- Vega: Spectral energy distribution with MgO/FeO and carbon for sizes 5-20 nm and 100 nm in a ring between 0.18-0.2 AU fit to observations in H-band, K-band and at 10.6 µm (Fig.3). Total dust mass equivalent to under 200 Halley comets
- Fomalhaut: Only the slope of the spectral energy distribution with MgO/FeO for sizes 5-20 nm and 100 nm in a ring 0.18-0.2 AU seem to fit observations in the K-band and N-band (Fig.4). Total dust mass equivalent to under 100 Halley comets
- Calculated beta-values show that sizes less than 1 µm are ejected from Vega and Fomalhaut due to radiation pressure
- Computed temperatures indicate that dust grains with size 5-100 nm are influenced by sublimation at 0.18-0.2 AU
- The temperatures suggest that the dust may only survive outward of 0.2 AU
- Future work can include modeling of spectral energy distribution at other distances and with other materials and sizes

Compare to observations:

Vega	Fomalhaut
K-band: 2.12 µm [1]	K-band: 2.18 µm [2]
H-band: 1.65 µm [3]	N-band: 8.25-12.69 µm [6]
Blinc: 10.6 µm [3]	

/ MODEL CALCULATIONS

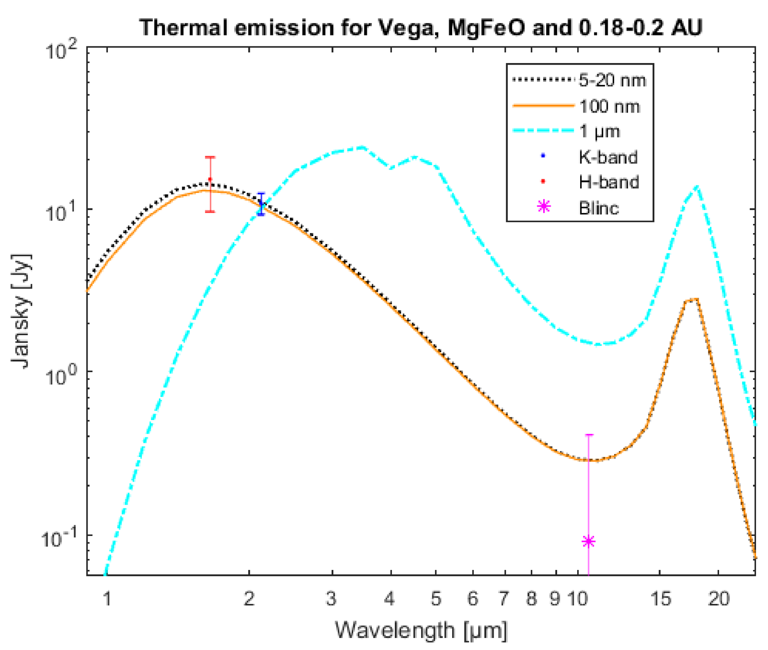

Figure 3: Spectral energy distribution derived for Vega with different sizes in a ring between 0.18-0.2 AU, dust consisting of a mixture of MgO and FeO

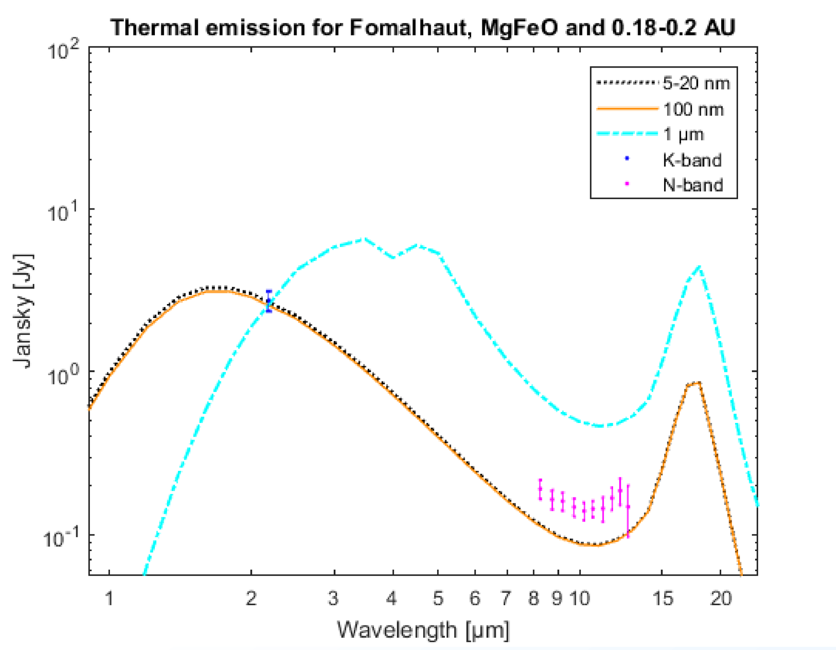

Figure 4: Spectral energy distribution derived for Fomalhaut with different sizes in a ring between 0.18-0.2 AU, dust consisting of a mixture of MgO and FeO

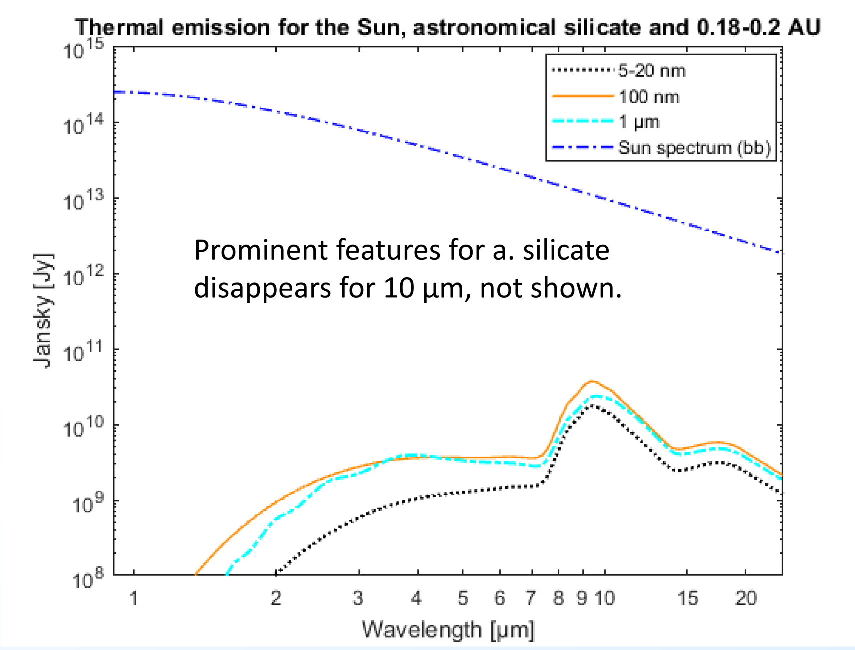

Figure 5: Spectral energy distribution derived for the Sun with different sizes at 0.18-0.2 AU, dust consisting of astronomical silicate

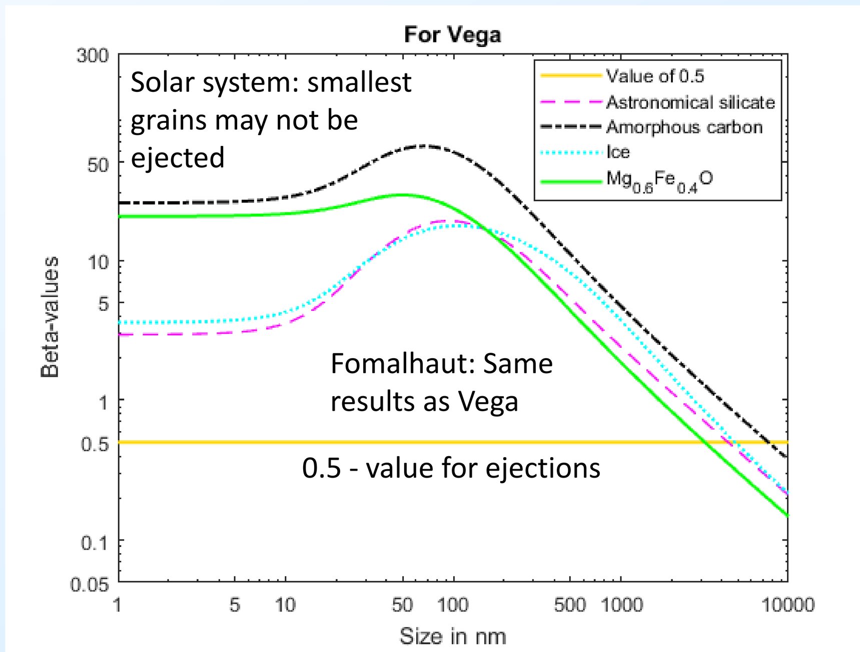

Figure 6: Beta-values computed as a sideproject, here shown for Vega. The beta-values were used in trajectory calculations by Johann Stamm, poster nr. X4.312

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