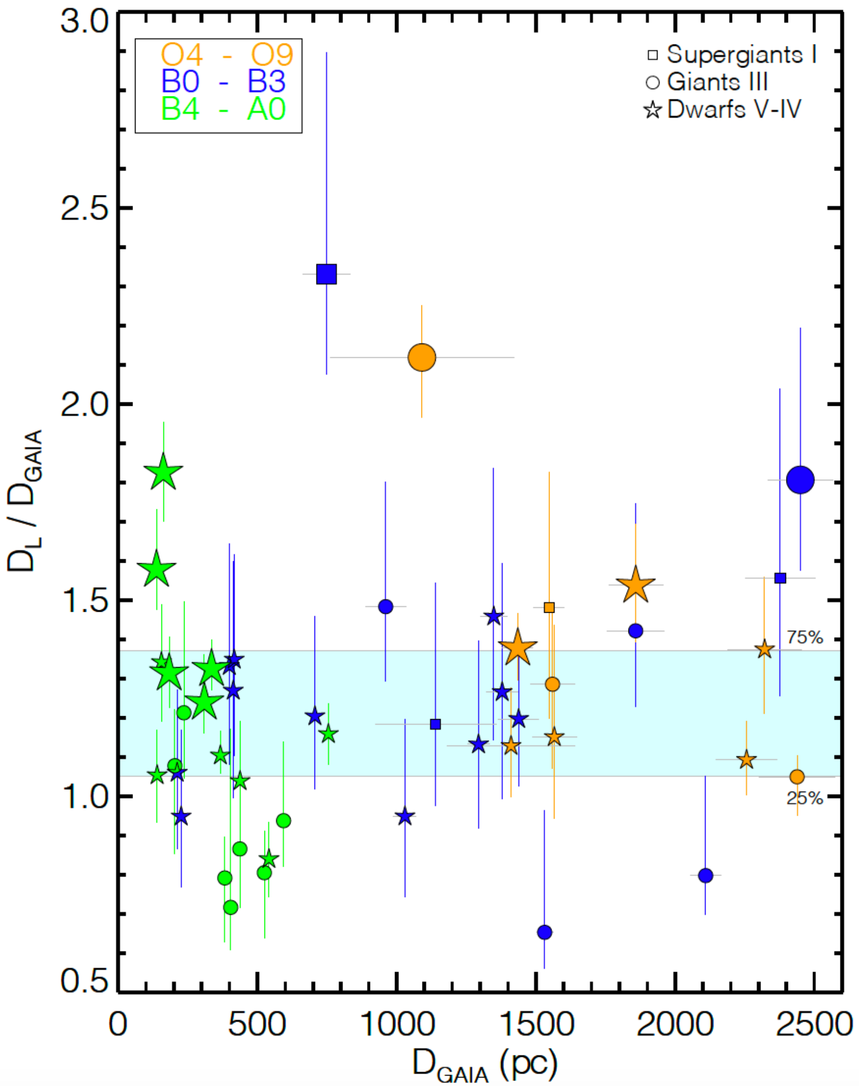
The distance to the stars

- The distance puzzle and very cold dust (Dark Dust IV)
- Dust model vs. observational constraints (Dark Dust II)
- Scrutinizing MW reddening curves (Dark Dust III)
- Model of the absolute reddening towards stars
- Unification of distances

The distance puzzle



$D_L > D_{GAIA}$ =>

Compensate overestimate

of luminosity viz. GAIA distance

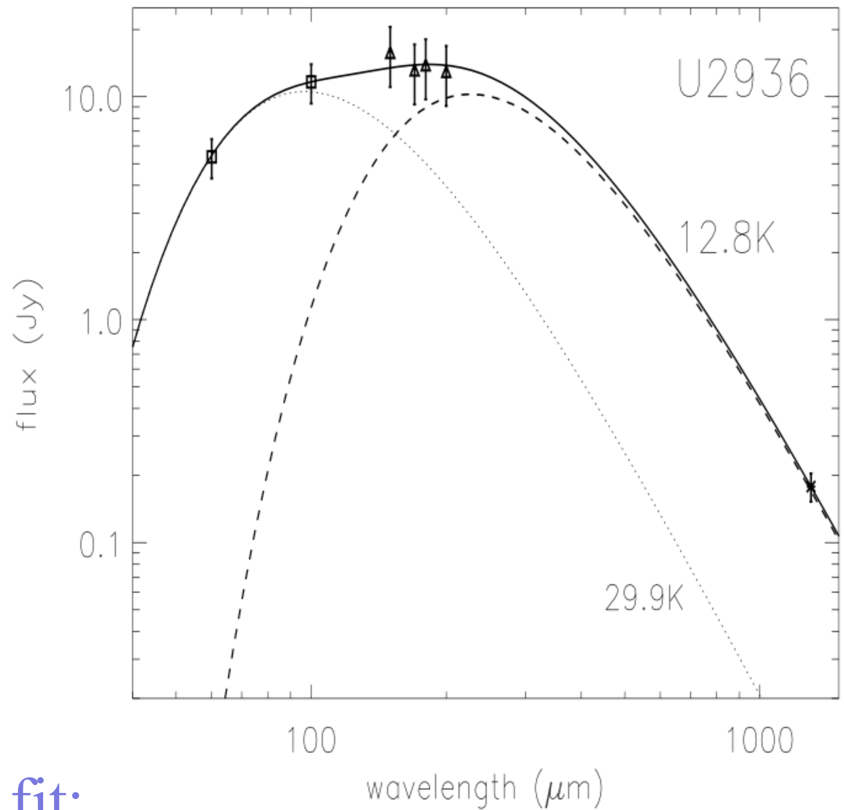
by extra dimming of the light.

$$5 \log(D_L) = V - M_V - A_V + 5$$

A_V : Valencic+04, Fitzpartick&Massa07, Gordon+09

M_V : Bowen+08, Wegner+07

The distance puzzle and **very cold dust** emission



Submm excess:
- ISO (S+99)
- Herschel
- ALMA

Degeneracy in SED fit:
- Chance of slope β (commonly applied)
- Dark Dust

Observational constraints of dust models (Hensley & Draine 21)

a) Solid phase element abundances

b) Wavelength dependant reddening

c) Star-light polarization

d) Dust emission of polarized + unpolarised light,

e) Account for increased (sub)mm emission in the MW by Planck

Dust populations:

1) Nano-particles	<6nm	of vSi, vGr, and PAH
2) Submicron spheroids	6nm < a < 300nm	of amorphous Si, C
3) Micrometer sized	dark dust	as fluffy Si+C conglomerates

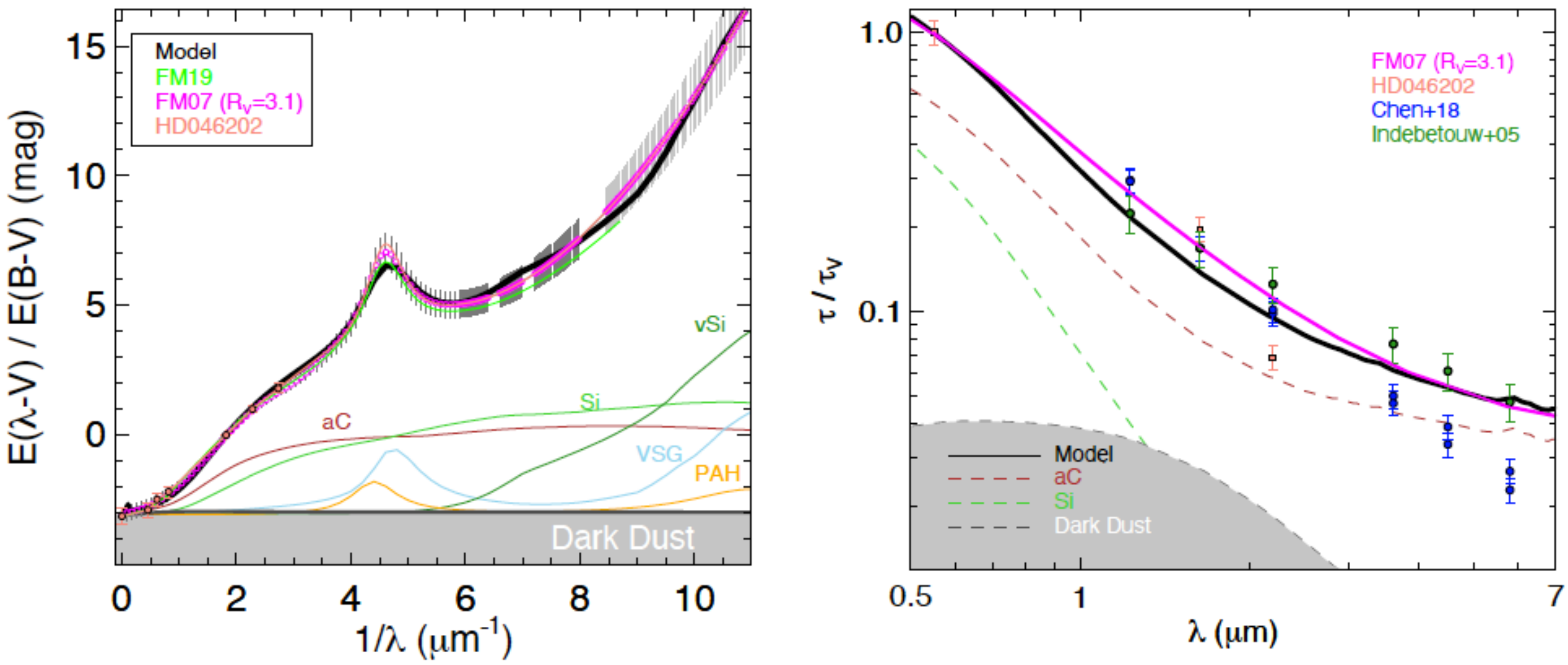
Model parameters (11):

- dust abundances (specific mass) of 6-1 components
- size parameters: exponent q, upper radii: r^{+}_{Si}, r^{+}_{C}, r^{+}_{μ}
- polarization alignment radii r^{p}_{Si}, r^{p}_{C}

a) Solid phase element abundances

All models respect: $[C] / [Si] < 5.2$

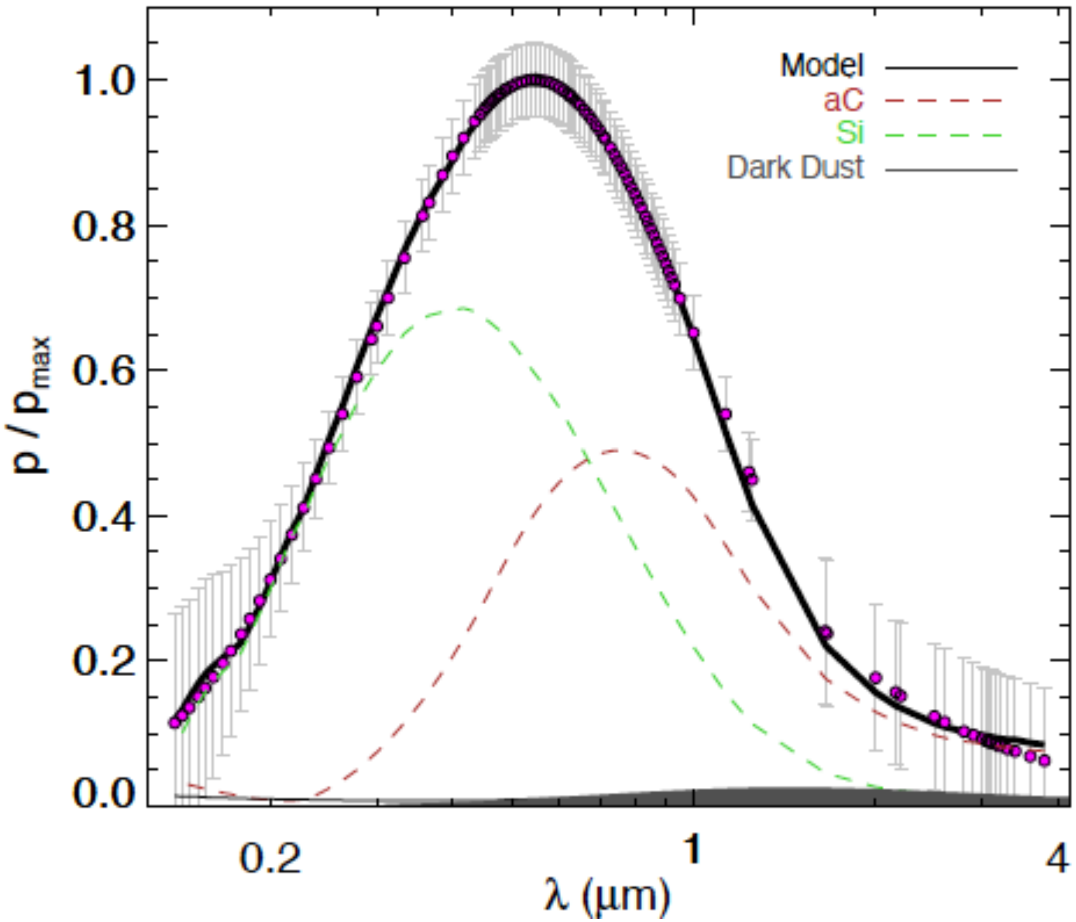
Dark Dust in the general field of the diffuse ISM
b) Reddening



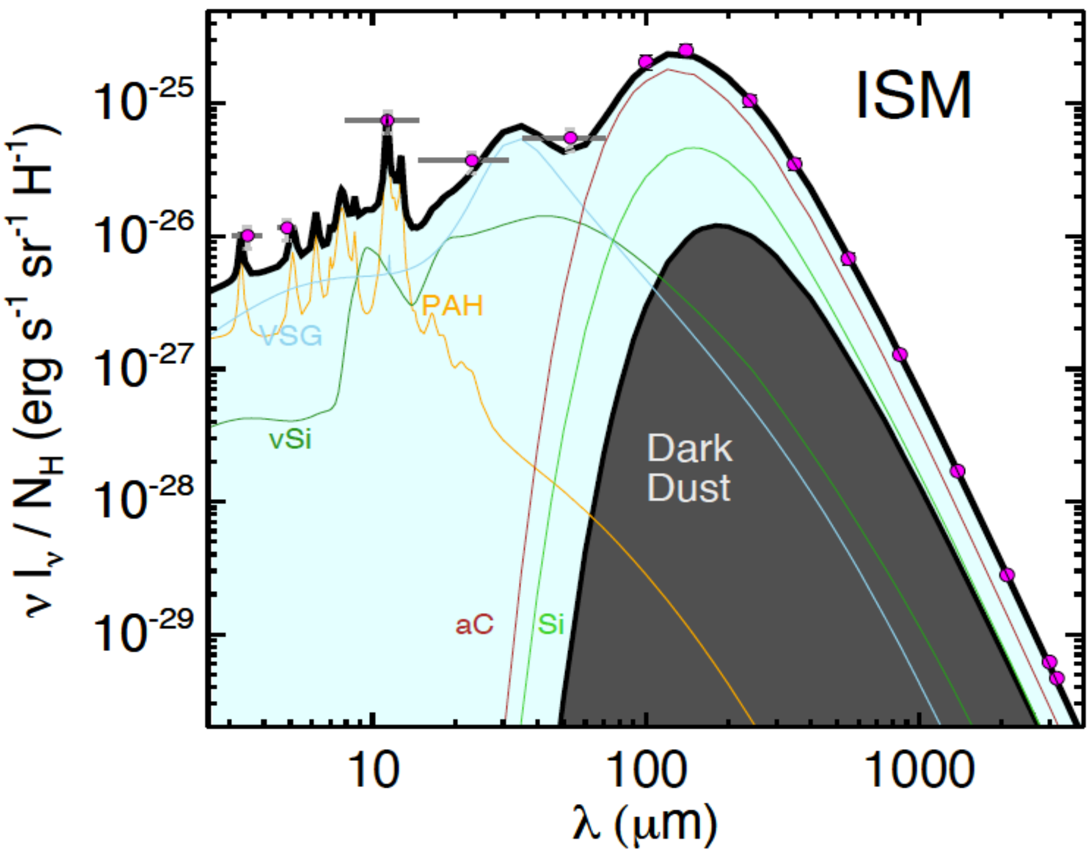
Dark dust reddening at $\lambda \leq 1\mu m$ is flat, non-selective, gray

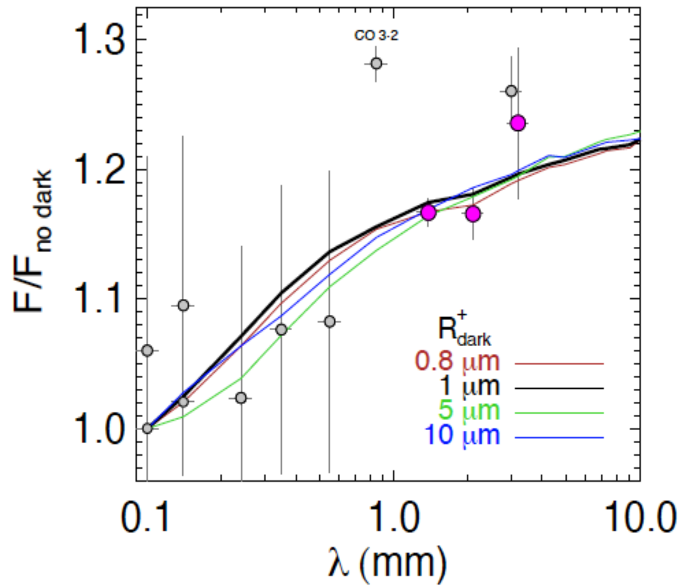
Dark Dust in the general field of the diffuse ISM

c) Starlight polarisation



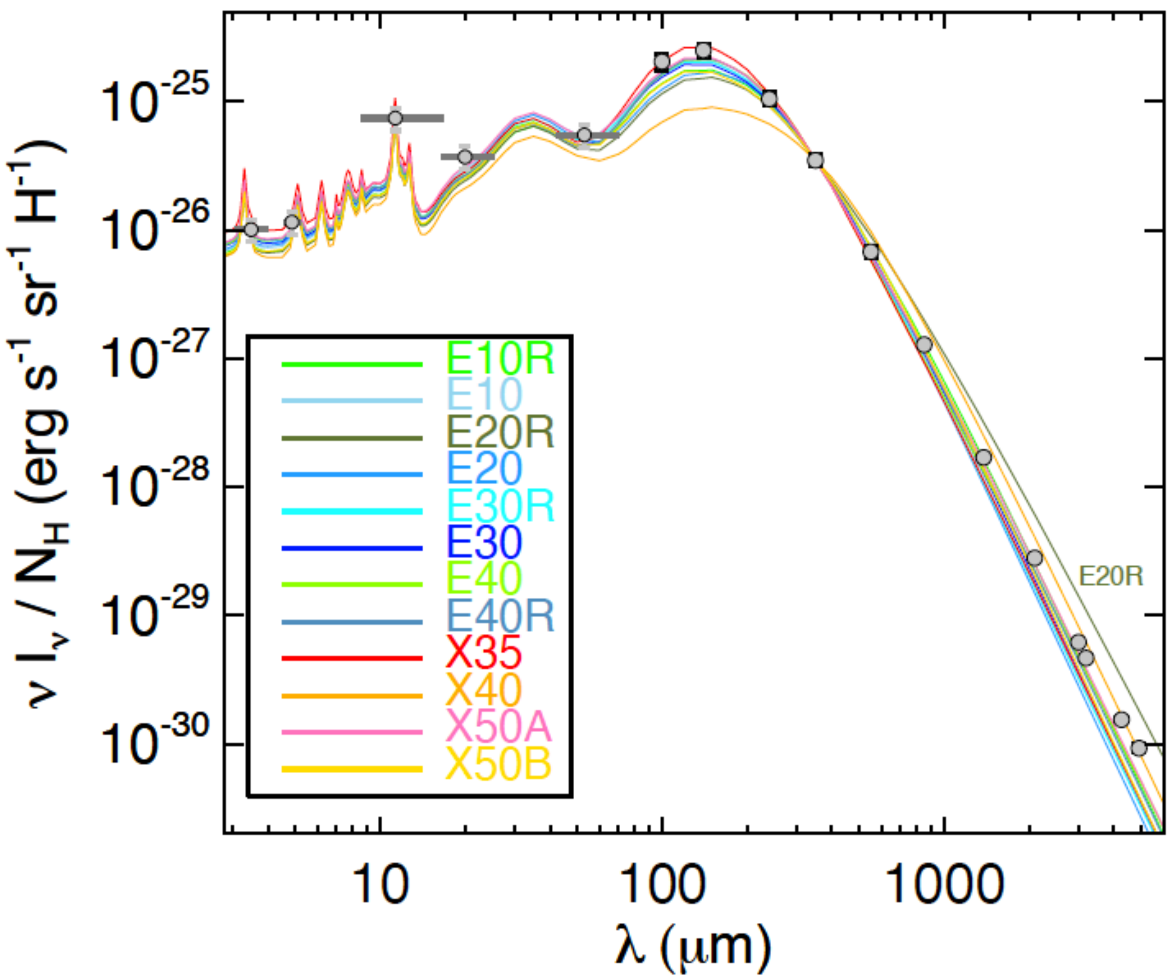
Dark Dust in the general field of the diffuse ISM
d) Emission + mm excess



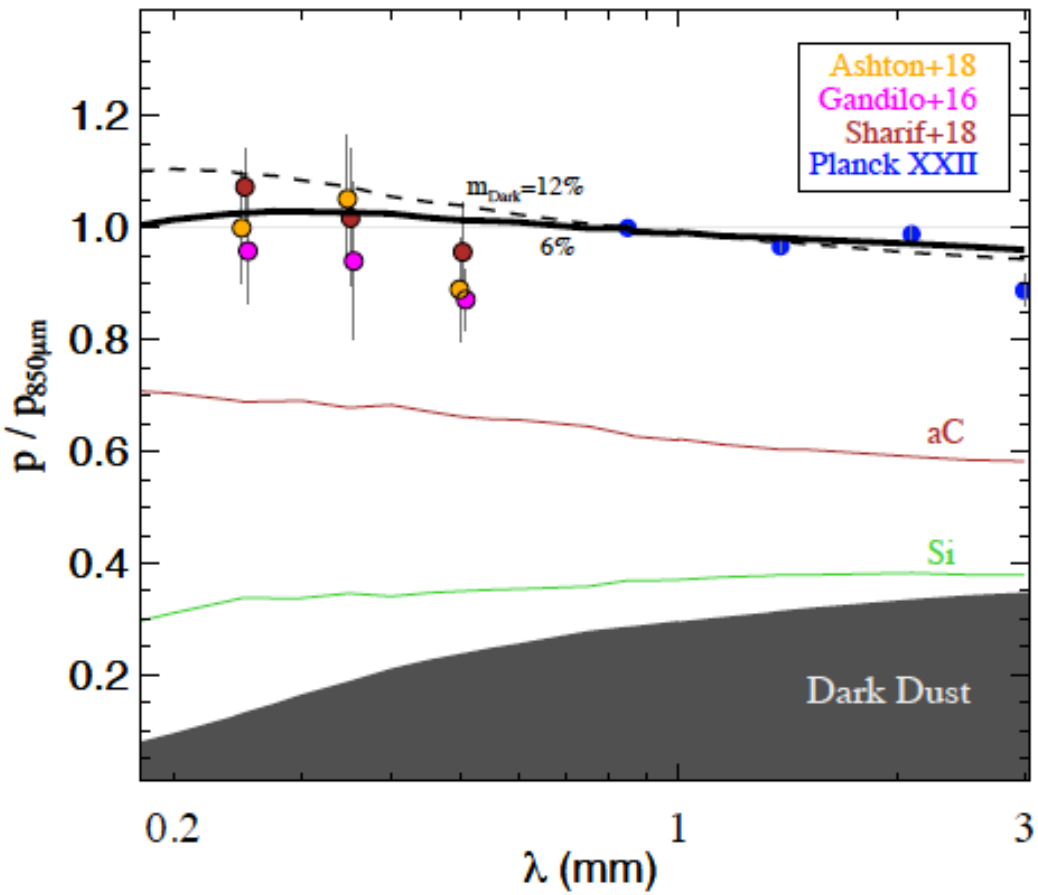


Dark Dust in the general field of the diffuse ISM

Mix of new (n,k) of amorphous Si (Karine Demyk+22)



Dark Dust in the general field of the diffuse ISM
d) Polarised emission



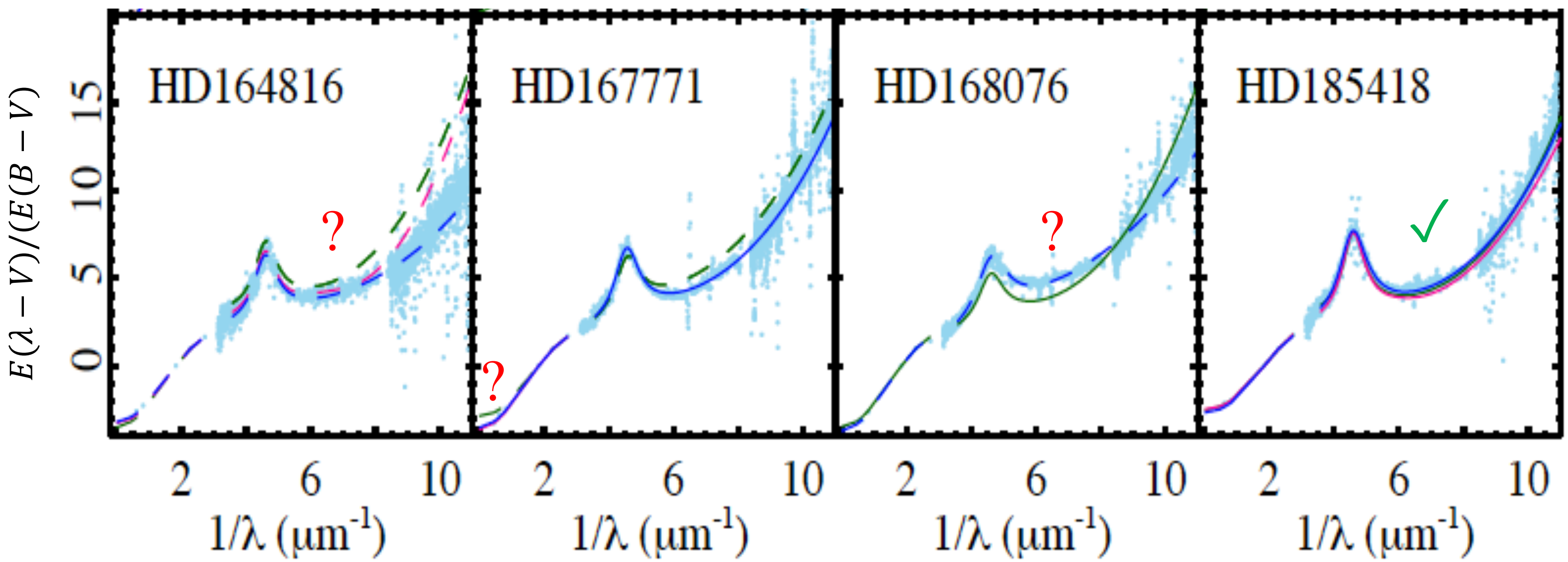
Submm/optical polarisation:

$$p_{850\mu m} \Big/ (p_V/\tau_V) = 4.3$$ (Planck: Guillet+16)

Dark Dust. III. The high-quality single-cloud reddening curve sample. Scrutinizing extinction curves in the Milky Way.

R. Siebenmorgen[1], J. Smoker[2,3], J. Krełowski[4], Karl Gordon[5], and Rolf Chini[6,7,8]

A&A 2023



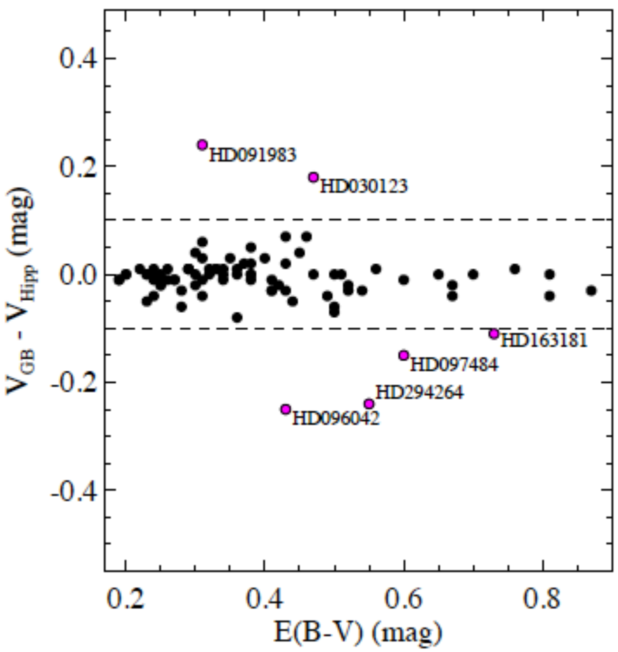
Legacy of reddening curves

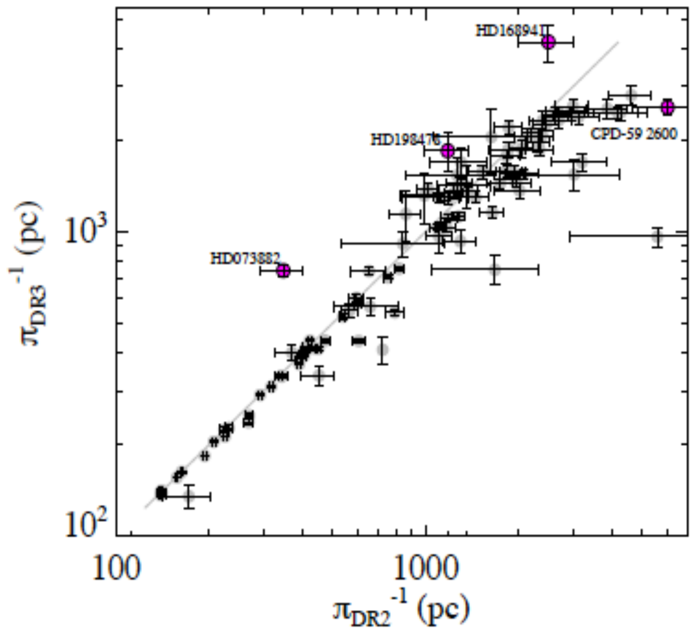
544	stars	IUE, FUSE
186	"	UVES spectroscopy
110	"	Large IS Polarisation Survey

=> **50** stars in high-quality sample

Dark dust III - High quality sample of reddening curves

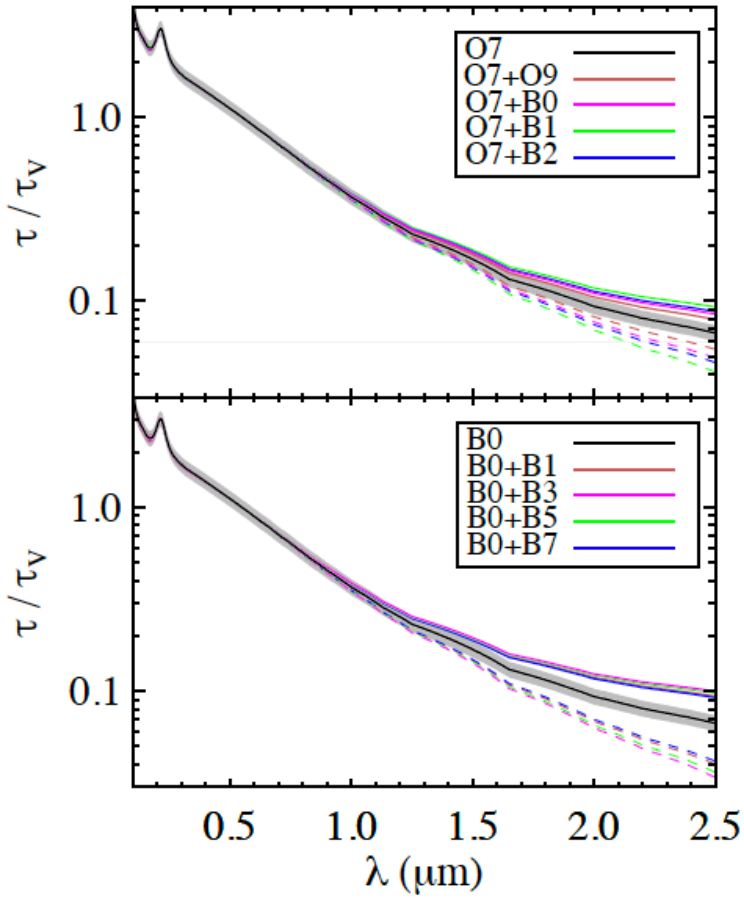
1. No multiple bright sources within 10″ ~IUE apertures
2. No variability in photometry
3. No variability in GAIA parallax
4. IR reddening: no emission components
5. Spec type + lum class of reddened +unreddened stars agree



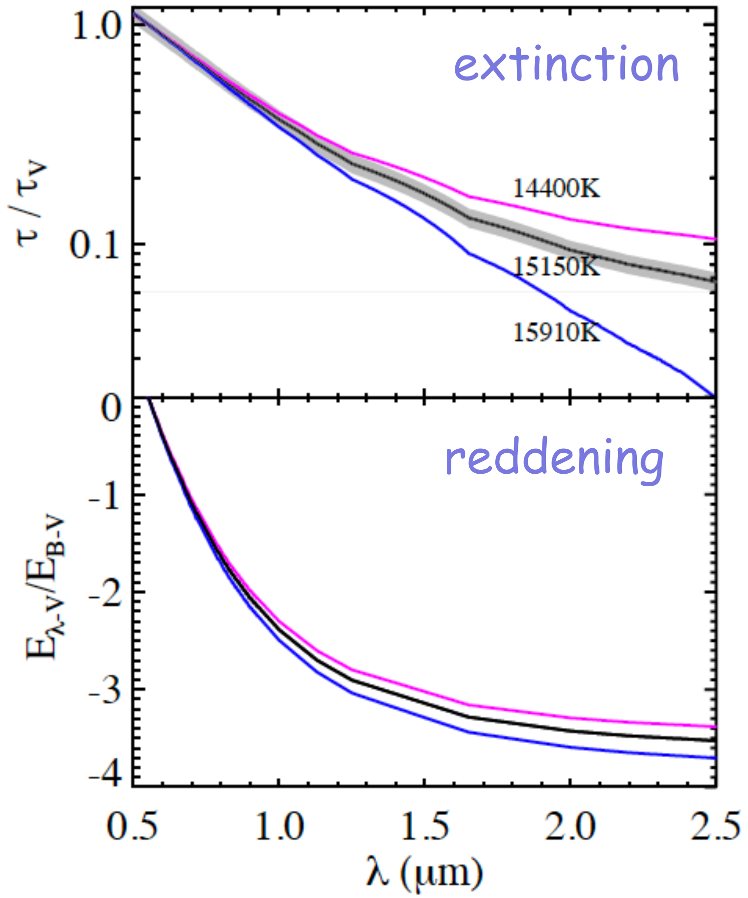


Scrutinizing extinction curves

Impact of binaries



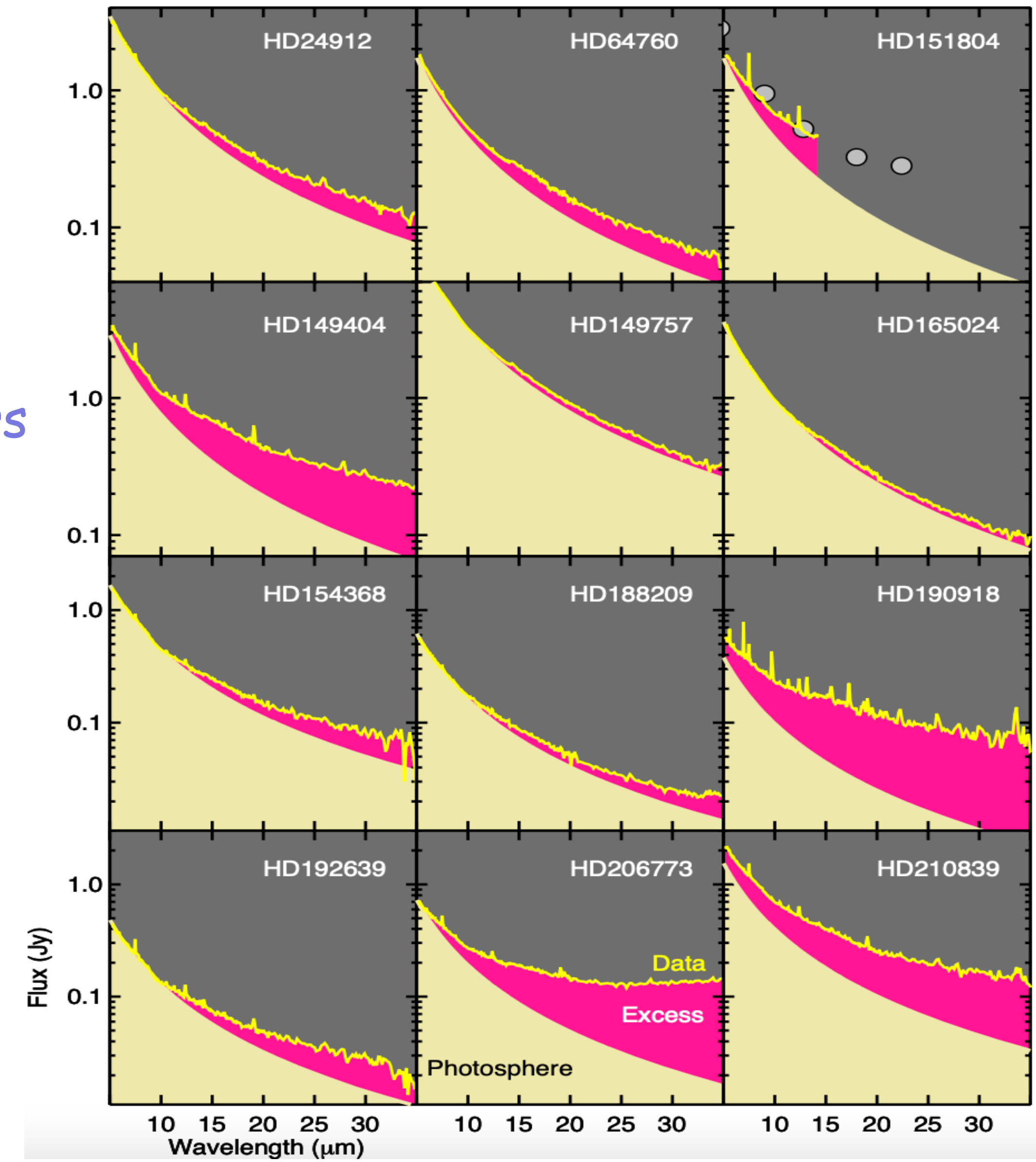
SpL of F_{obs} and F_{nd} differ

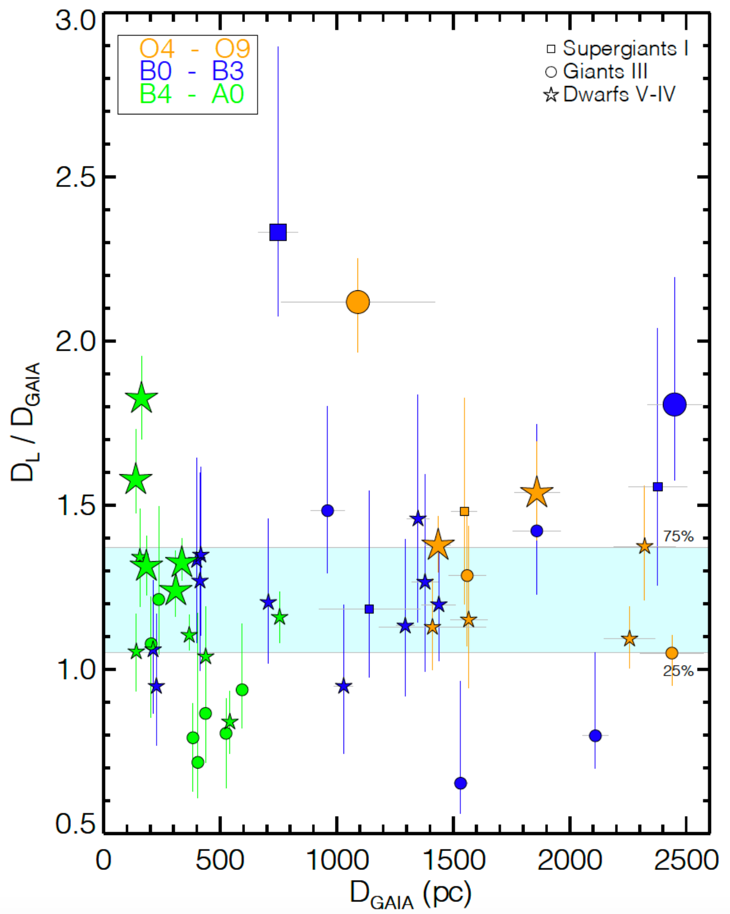


Impact on reddening in the NIR is large

Scrutinizing MIR reddening curves

~50% of OB stars show MIR/FIR excess emission





Dimming by :

- ‘meteoritic bodies’(Trumpler, 1930)
- μm –sized grains (Dark Dust II, 2023)

Distance unification by dark dust

1) Estimate A_V by inserting D_{GAIA} in photometric equation:

$$A_V = V - M_V - 5 \log D_{GAIA} + 5.$$

$\tau_V = N^n K^n_V + N^\mu K^\mu_V$ Dark Dust model with extinction cross section K

$\tau_V < E(H)/1.086$ reddening at infinite is smaller than in H-band

2) Normalize $N^{n,\mu}$ by observed E(B-V)

$$E(B-V) = 1.086 (\tau_B - \tau_V)$$

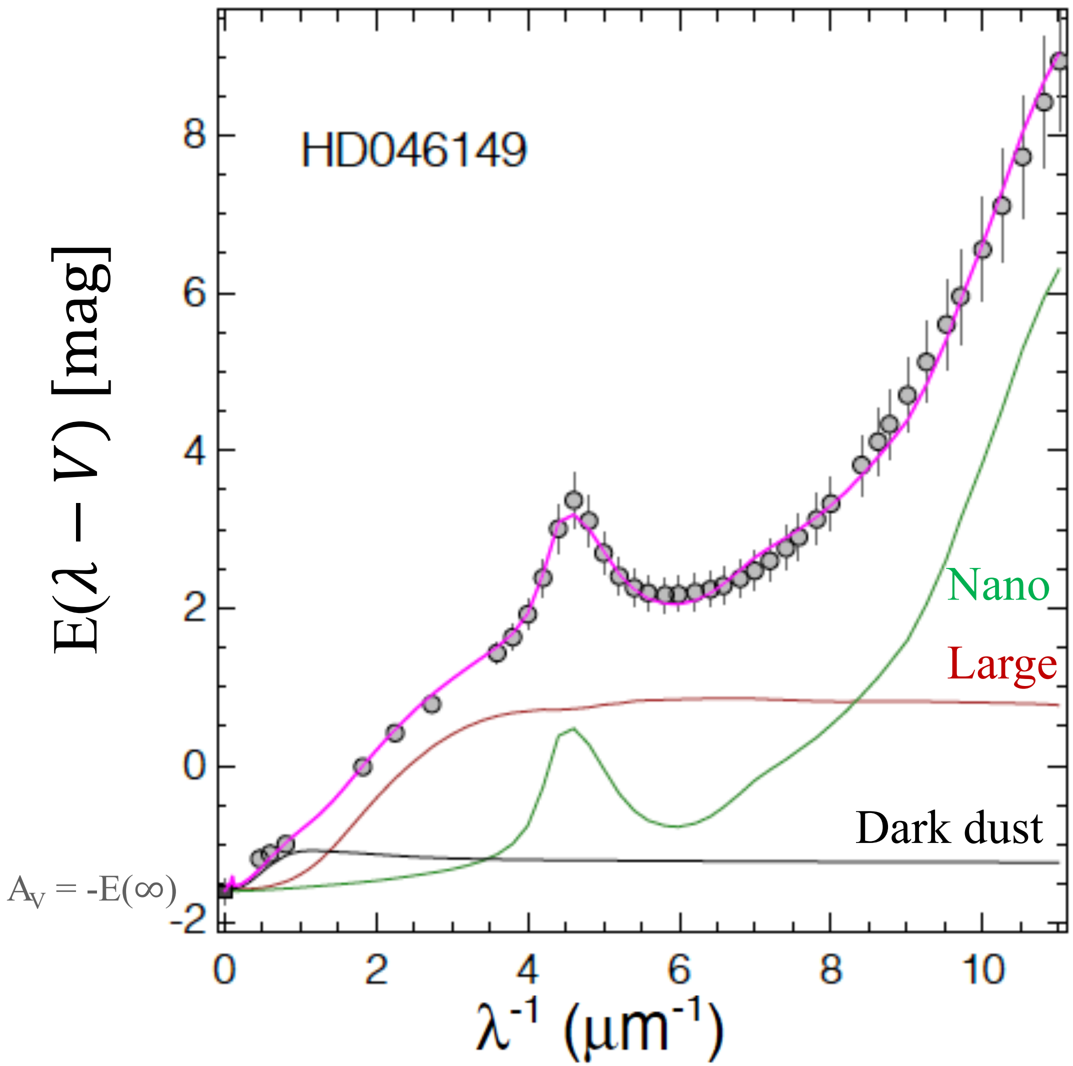
$$(\tau_B - \tau_V) = N^n (K^n_B - K^n_V) + N^\mu (K^\mu_B - K^\mu_V)$$

=>

- Model of the absolute reddening
- $D_L = D_{GAIA}$

Model of the absolute reddening

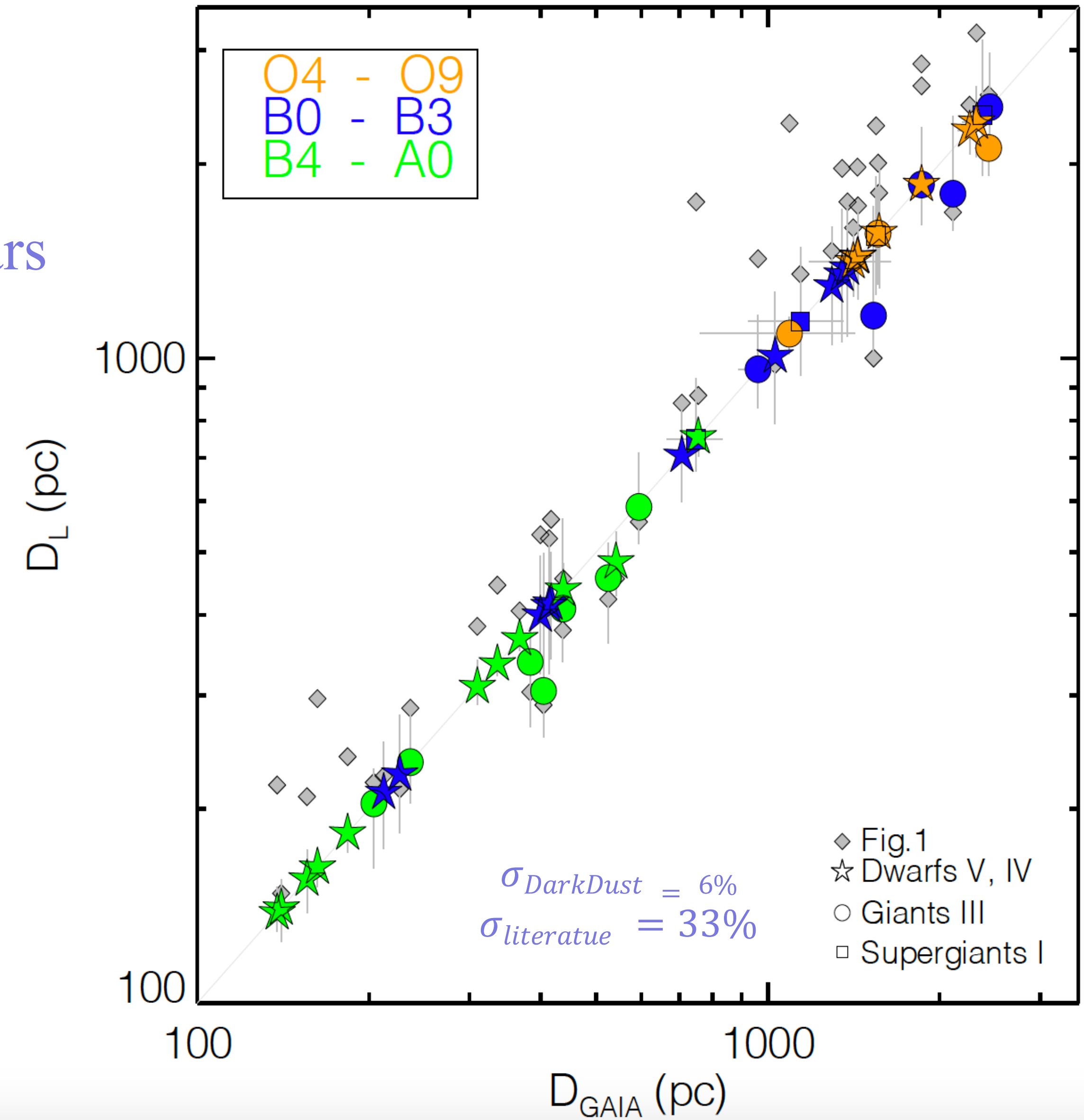
Fit all 47 stars



Distance unification

$D_L = D_{GAIA}$

for 40 out of 47 stars

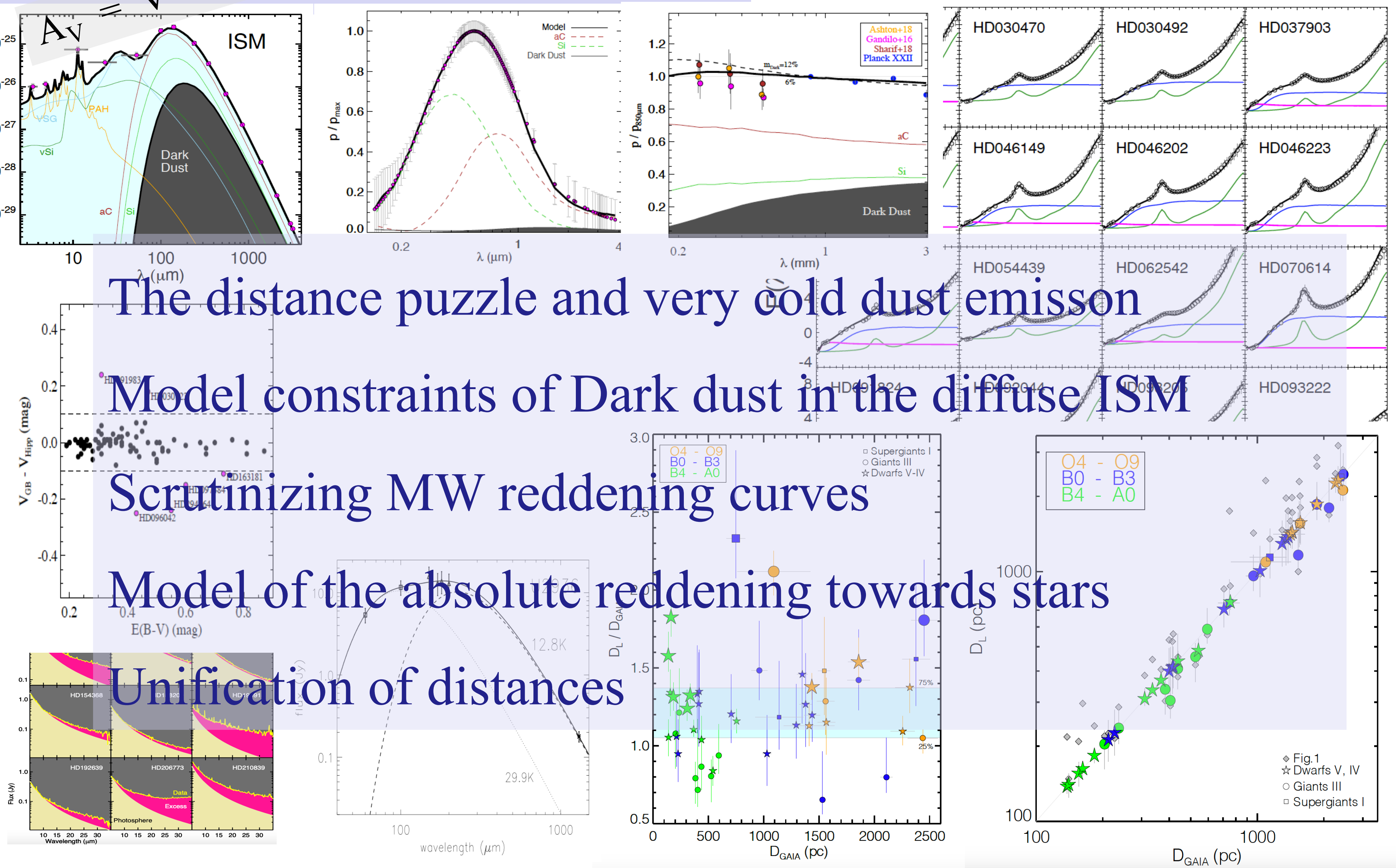


Dark Dust and the unification of distances to the stars

- The distance puzzle and very cold dust emission
- Dark dust a new component of the ISM
- Reddening of stars: NIR be careful, R_V be very careful
- Model of the absolute reddening towards stars
- Unification of distances: $D_L = D_{GAIA}$

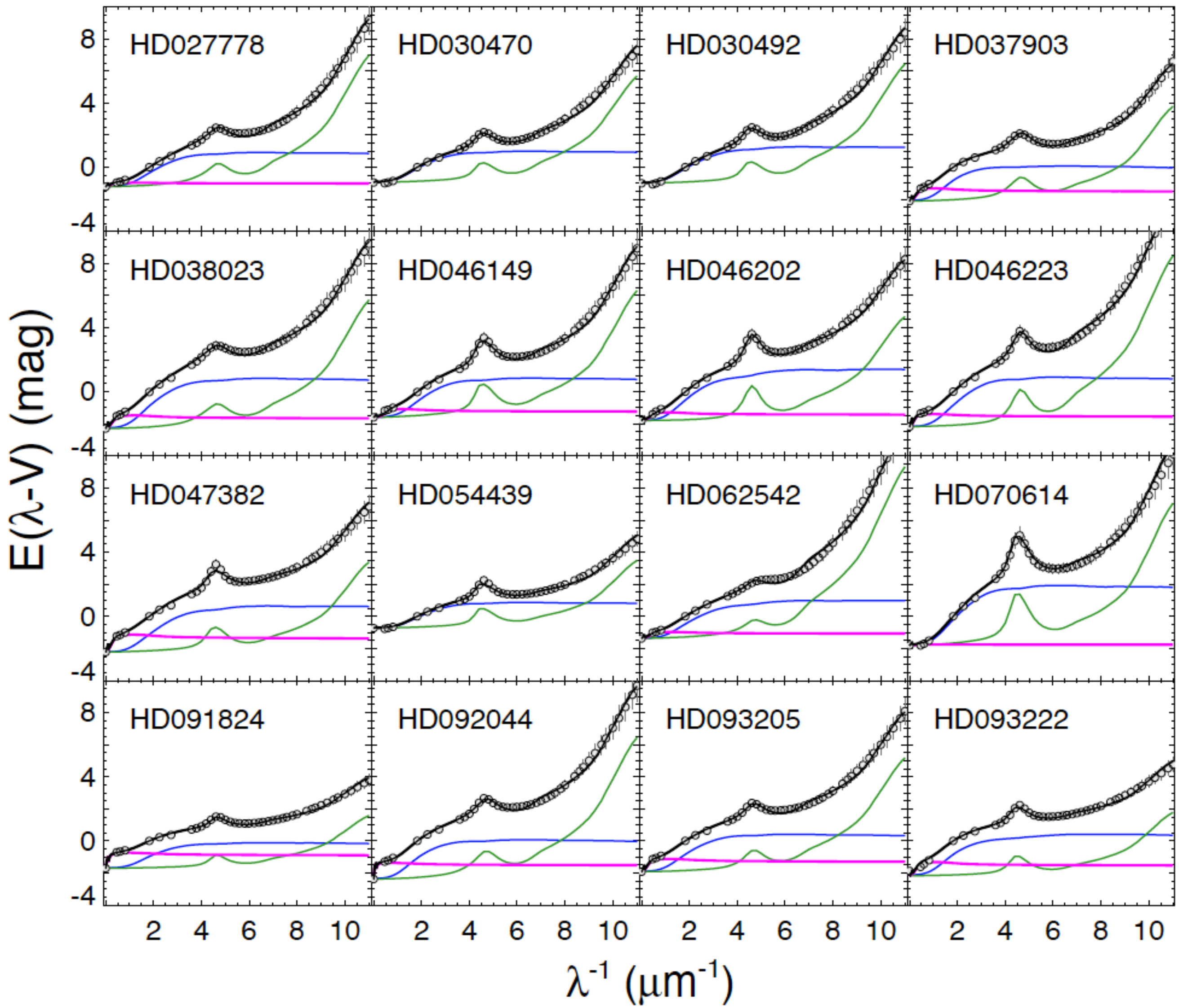
Dark Dust IV
The distance to the stars

$$A_V = V - M_V - 5 \log D_{GAIA} + 5.$$



- The distance puzzle and very cold dust emisson
- Model constraints of Dark dust in the diffuse ISM
- Scrutinizing MW reddening curves
- Model of the absolute reddening towards stars
- Unification of distances

Distance unification
Model of the absolute reddening



Fit all 47 star

Extinction fit

$$\left(\frac{\tau(\nu)}{\tau_V}\right)_{\rm obs} \sim \left(\frac{K_{\rm ext}(\nu)}{K_{\rm ext,V}}\right)_{\rm model}$$

Dust attenuation $A(\nu) = 1.086\,\tau_{\rm ext}(\nu)$

$$K_{\rm ext} = \sum_i \int_{r_-}^{r_+} K_{{\rm ext},i}(r)\,{\rm d}r$$

Dust extinction cross section

$$K_{{\rm ext},i}(r) = \frac{w_i}{\frac{4\pi}{3}\rho_i}\,\frac{r^{-q}}{\int_{r_{-,i}}^{r_{+,i}} r^{3-q}\,{\rm d}r}\,C_{{\rm ext},i}(r)$$

..of particle of population

$i \in \{{\rm Si, aC, sSi, gr}\}$, of radius r and density ρ_i

$$w_{\rm aC} = \frac{\Upsilon_{\rm aC}\,\mu_{\rm C}}{(\Upsilon_{\rm aC} + \Upsilon_{\rm gr} + \Upsilon_{\rm PAH})\mu_{\rm C} + (\Upsilon_{\rm Si} + \Upsilon_{\rm sSi})\mu_{\rm Si}}$$

Specific mass requies realtive dust abundances

Siebenmorgen et al. (2014)