Figure: Emil Ivanov, Sterne und Weltraum

An unbiased survey for exozodiacal dust

New results from VLTI/PIONIER

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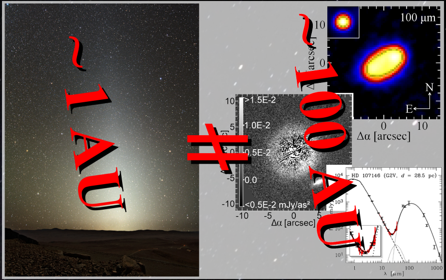
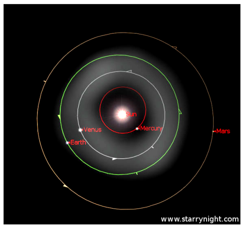
Exozodiacal dust

What is exozodiacal dust?

- Dust around main sequence stars, sublimation to few AU
- Analog to our zodiacal dust
- **NOT** a typical debris disk



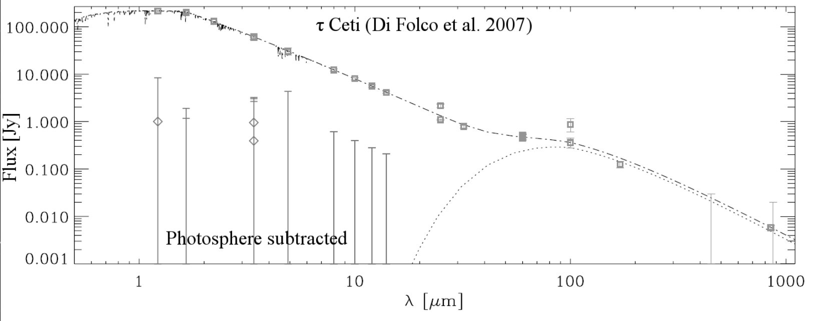
Why do we care?



- Dust in the habitable zone
- Structures might point towards planets
- **BUT:** Obstacle for imaging of earthlike planets

Exozodiacal dust

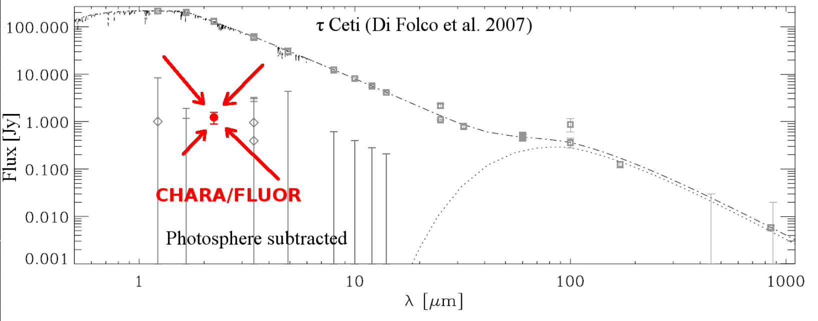
How to detect exozodiacal dust?



- Our zodiacal dust is the most luminous component of our Solar System
- However, it would be too faint to be detected, e.g., by *Spitzer* (more than 100 times) or *WISE*

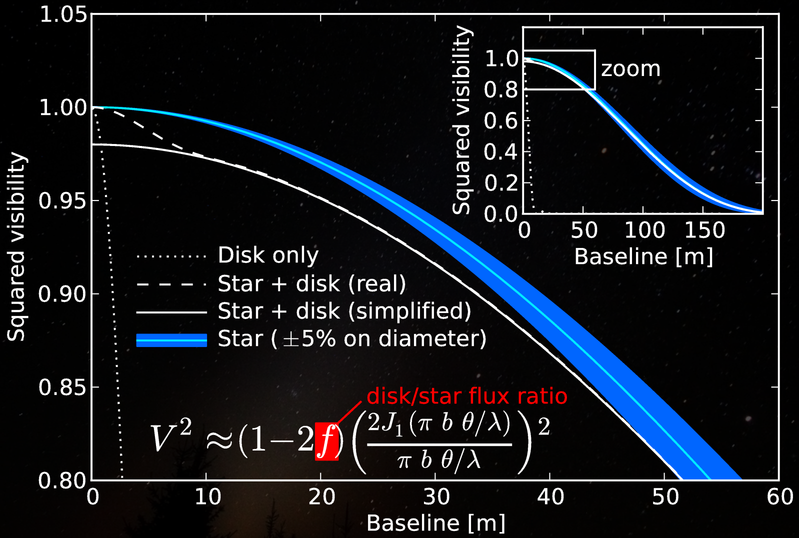
Exozodiacal dust

How to detect exozodiacal dust?



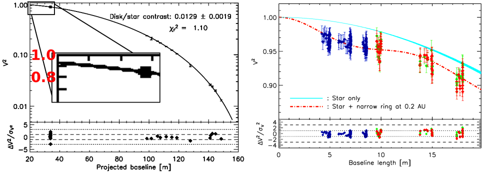
- Emission alone would be detectable (10 mJy to 1 Jy), problem is photometric calibration or angular resolution
- Solution: infrared interferometry in order to disentangle stellar emission and dust emission

Detection strategy

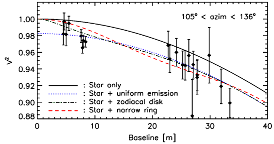


Exozodiacal dust

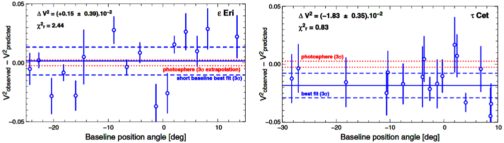
Nice, but does it work?



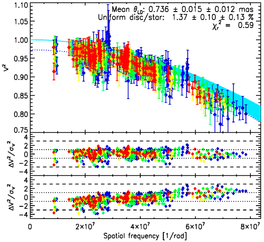
Vega. left: CHARA/FLUOR (Absil et al. 2006)
right: VLTI/VINCI (Defrere et al. 2011)



Fomalhaut. VLTI/VINCI, Absil et al. (2009)



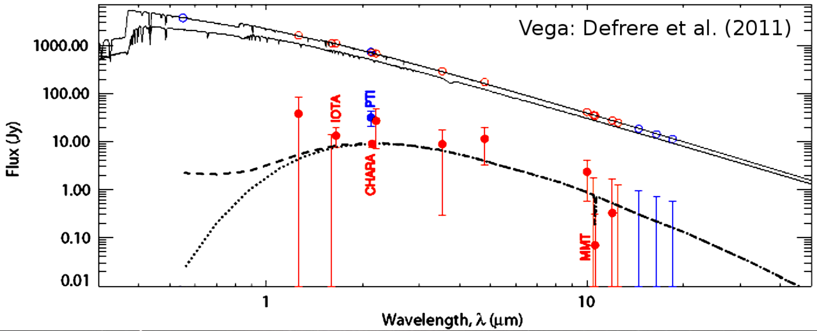
Di Folco et al. (2007), Chara/FLUOR.
left: ε Eri (no excess), right: τ Ceti (excess)



β Pic. PIONIER, Defrere et al. (2012)

Other observations: *Keck* nuller (Millan-Gabet et al., 2011), *Spitzer*, *WISE*

So, what do we learn from first detections?



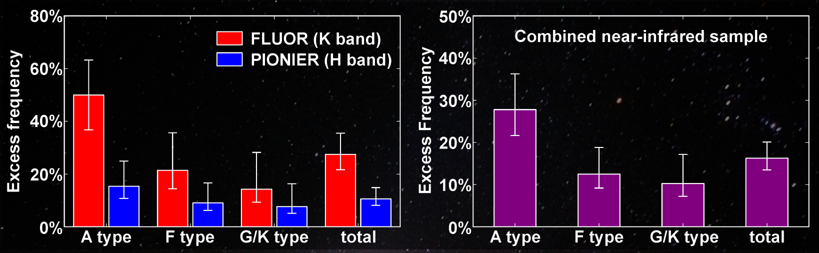
- Very small grains (< blow-out size), hot, close to sublimation temperature/distance
- Dust mass $\sim 10^{-10}$ to $10^{-9} M_{\mathrm{earth}}$
- Dust removal time scale ~ 1 year
- Vega only one example, similar for Fomalhaut, β Pic

The EXOZODI *Survey(s)*

Several possible origins of exozodiacal dust, but all have problems (Bonsor et al., 2012a, 2012b, 2013):

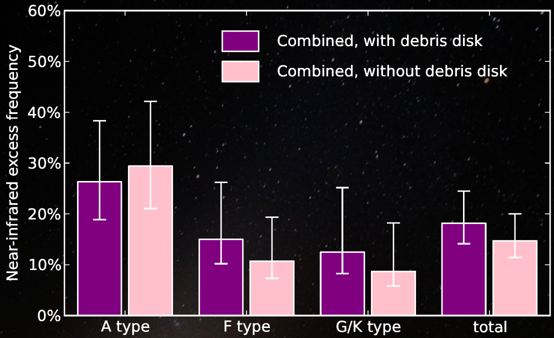
- Local collisions of large bodies
  - High amount vs. short lifetime of the dust
  - ⇒ **Statistics** of frequency/dust mass vs. age
- Recent planetary collision
  - Low probability vs. high detection rate?
  - ⇒ **Statistics** of frequency among stars in general
- Evaporation of comets/dust transport from outer disk
  - Large number of comets required (LHB?)
  - ⇒ **Statistics** of correlation between exozodis and exo-Kuiper belts

Statistics based on ~130 stars observed:



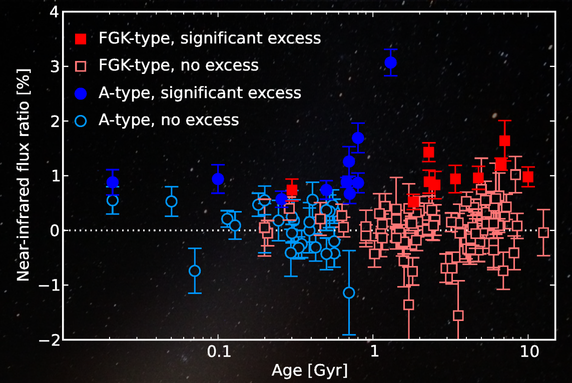
- Detection rate with FLUOR (*K* band) by factor of ~2.5 higher than with PIONIER (*H* band)
- Correcting for this factor all statistics consistent between the two samples
- Detection rate decreasing with later spectral type
  ⇒ ***Like a normal debris disk?***

Statistics based on ~130 stars observed:



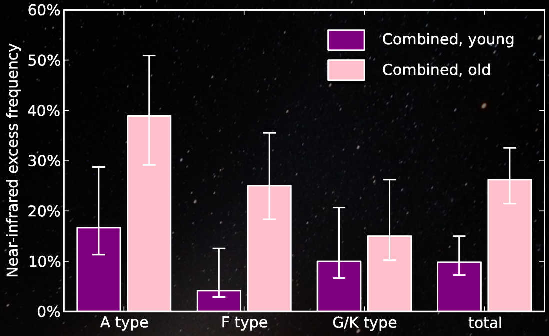
- No correlation with presence of cold dust
  ⇒ ***Not the same phenomenon!***

Statistics based on ~130 stars observed:



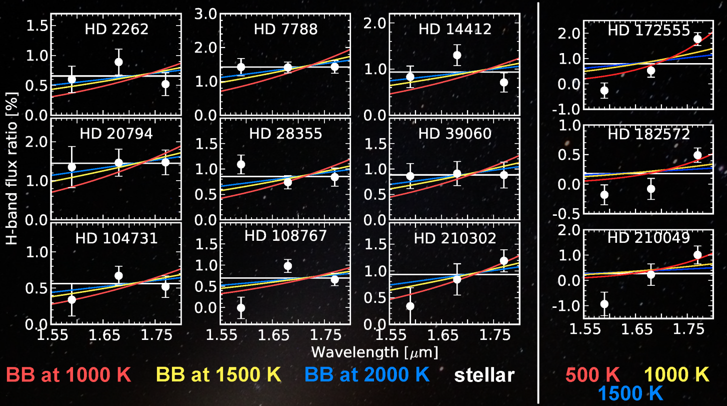
- No clear correlation with age
- If any, slight increase of excess with age?
  ⇒ ***No (simple) collisional equilibrium!***

Statistics based on ~130 stars observed:



- Separate each spectral type bin in stars younger and ones older than median age in bin
- Tentative ***increase*** of detection rate with age
  ⇒ ***Some trapping mechanism?***

H band colors from PIONIER:



- Scattered light / extremely hot for some targets, others thermal emission – DIVERSITY
- *K* band vs. *H* band detection rate:
  Dust warm, *H* dominated by scattered light?

Conclusions from the EXOZODI project

- ~1/5 of all main sequence stars near-IR bright exozodiacal dust
- Increase of detection rate from *H* (∼11%) to *K* (∼30%)
- Most likely not related to presence of outer debris disk (in contrast to mid-IR detected dust, Mennesson et al., subm.)
- Very hard to explain, no clear, working scenario so far
- Potentially strong contribution of scattered light in near-IR

Near future

- So far just **PIONIER**ing, soon VLTI/GRAVITY, VLTI/MATISSE
- Full characterization of the dust SED
- Very detailed characterization of all survey detections
- Connection between hot, warm, and cold dust in a system
- Real connection to dust in the habitable zone
- Long term variability surveys

Thanks a lot!