Summary of hot dust workshop

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Steve's fault

eso1435-en-us — Science Release

SPACE SCOOP

VLTI Detects Exozodiacal Light

New challenge for direct imaging of exo-Earths

3 November 2014

Ertel et al. 2014

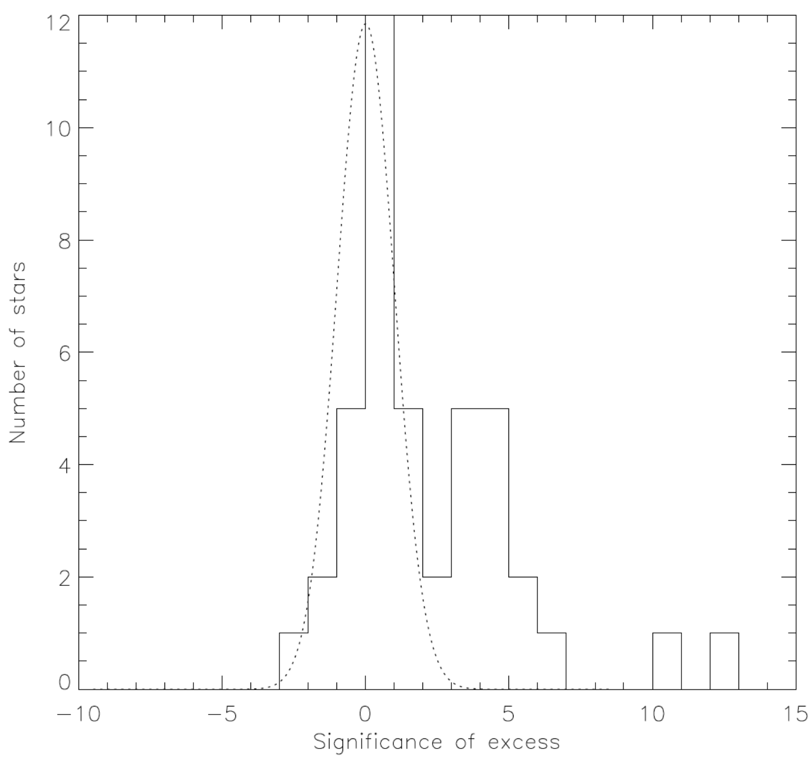
Introduction

Hot dust workshop: May 20-22 (2015) -- Caltech

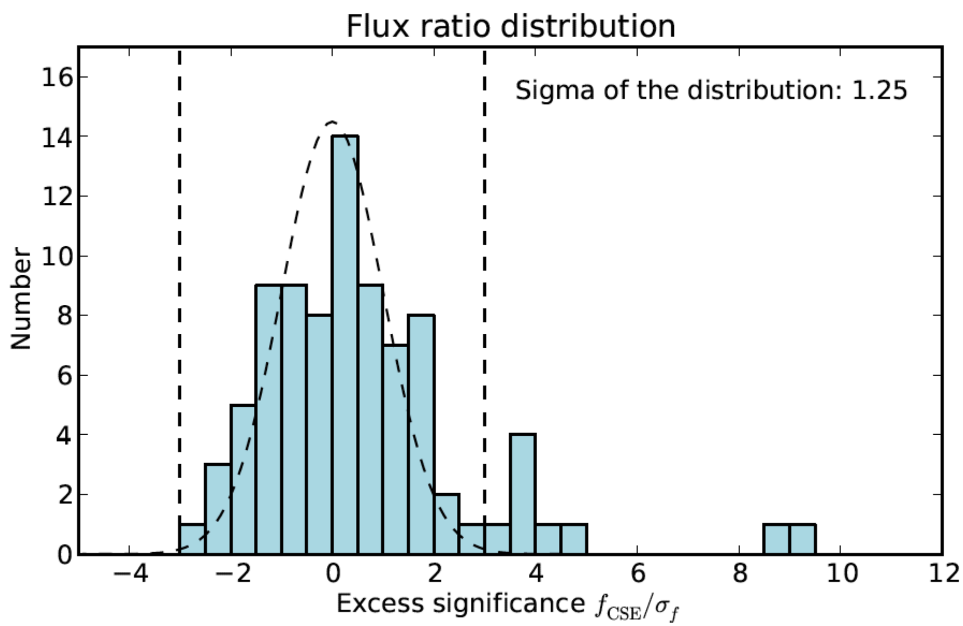
Morning	**Hot Excess Phenomenon Observational Facts**	Moderator: Olivier Absil
8:15 am	Coffee/Light Breakfast	
8:30 am	Introduction, Welcome, and Meeting Objectives	Rafael Millan-Gabet, Theo ten Brummelaar & Bertrand Mennesson
8:40 am	Statement of the problem and review, including programmatic implications	Bertrand Mennesson
9:10 am	Near Infrared High Resolution Measurements (CHARA, VLTI, PFN)	Steve Ertel
9:40 am	Mid Infrared High Resolution Measurements (KIN, MMT, LBTI)	Denis Defrere
10:10 am	Coffee Break	
10:30 am	NIR Spectroscopic Measurements	Casey Lisse
11:00 am	MIR/FIR Spectroscopic Measurements & Variability	Kate Su
11:30 am	Lunch Break	
Afternoon	**Current Theories**	Moderator: Geoff Bryden
1:00 pm	Radiative Transfer Modeling & Hot Dust properties	Jeremy Lebreton
1:20 pm	Theoretical difficulties with standard models (Wyatt) and Different Potential Numerical Approaches to Model Exozodis (Kral)	Mark Wyatt, Quentin Kral
2:00 pm	Creation, transport to the inner zone and evaporation of comets	Virginie Faramaz
2:30 pm	Coffee Break	
2:50 pm	Dynamical trapping (pile-up) of grains near the sublimation radius	Hiroshi Kobayashi
3:10 pm	Magnetic trapping of small dust grains	George Rieke
3:30 pm	Trapping mechanisms: the effect of gas	Geoff Bryden
3:45 pm	The view of solar and stellar physics/the case of Be stars	Geoff Bryden, others
4:00 pm	reserve/discussion	
4:30 pm	adjourn	

Controversial

1. Observational aspects:
   - Most detection at 3-5 sigmas



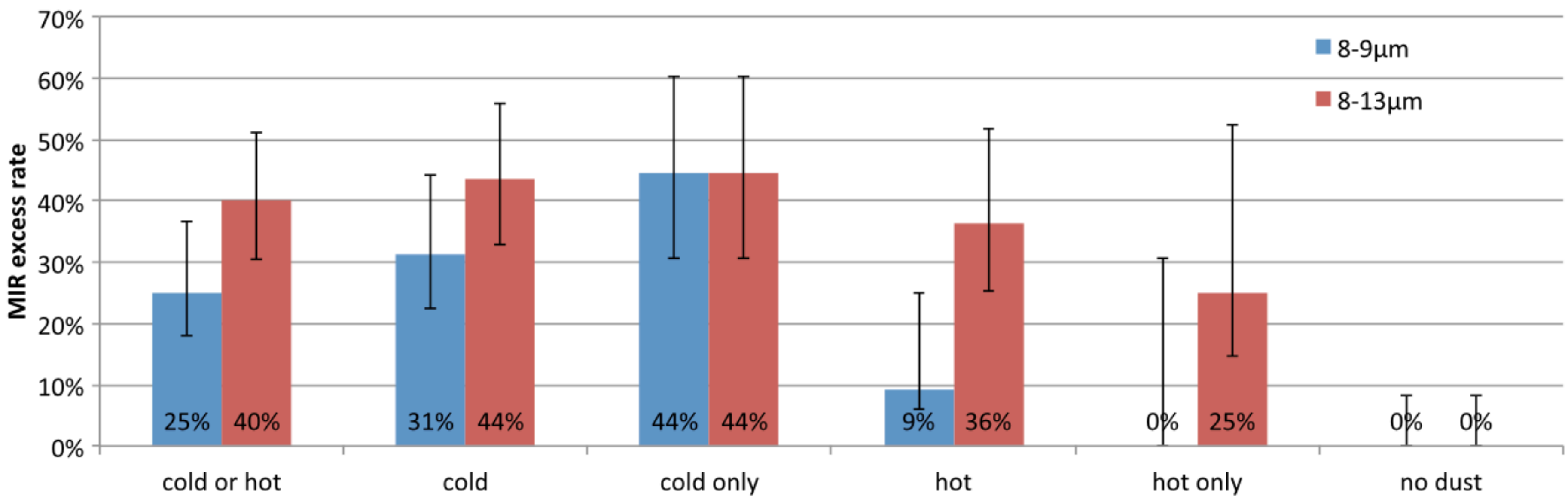
CHARA/FLUOR – K band



VLTI/PIONIER – H band

Controversial

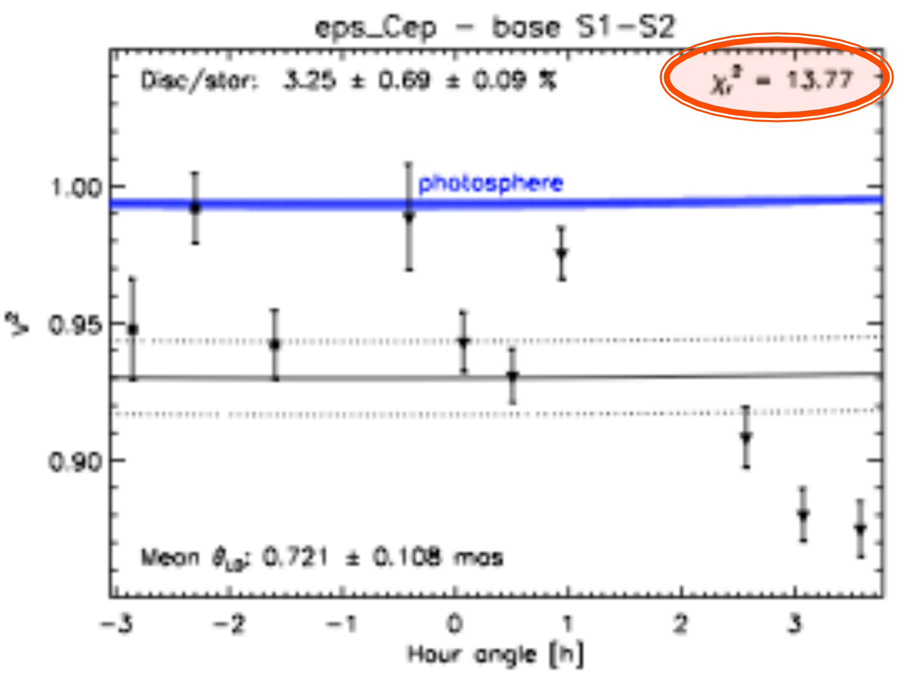
1. Observational aspects:
   - No correlation with warm dust



Controversial

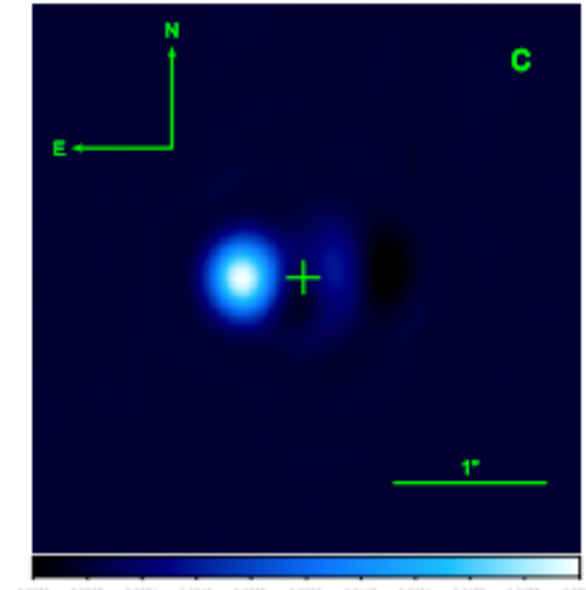
1. Observational aspects:
    - Detected with 3 different interferometric instruments
    - Detection confirmed by direct imaging

2008-2009 FLUOR data



2010 coronagraphic image (Palomar)

Mawet et al. 2011



K8-M2 companion
K=7.8
>8.6 AU (>320 mas)

Controversial

2. Theoretical aspects:
   - Such small dust particles should be expelled by RP in very short timescales (?)
   - But NIR excess is observed around many stars
   - Dust must either be replenished quasi continuously
     - Is there enough supply for that?
   - Or trapped in the inner region
     - How?
   - Alternative scenarios? Is it really dust?

Where does the excess come from?

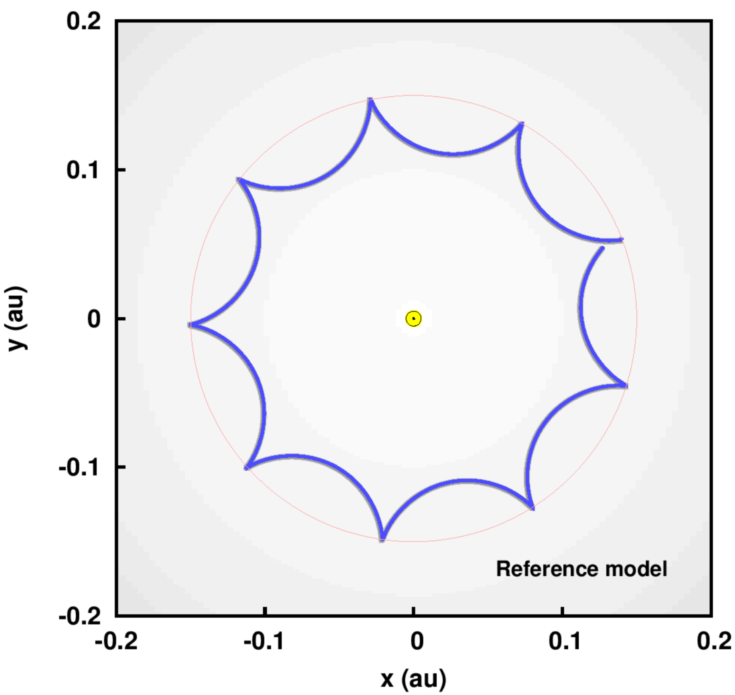
Basic constraints:

- CHARA/FLUOR FoV = 0.5” FWHM, VLTI/PIONIER = 0.2” FWHM
- $V = V_s.(1-f) + f.V_d$ → resolved excess detectable as close as 5mas with CHARA 34m baseline at 2.2 μm

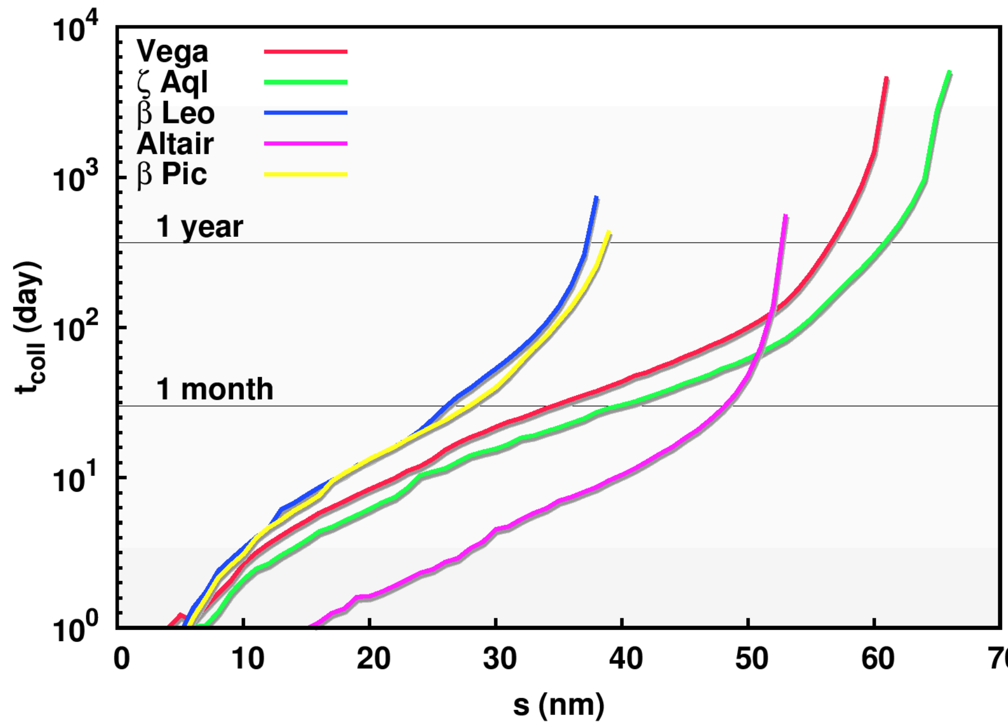
tau Cet	G8V	4.7 Rstar
10 Tau	F9V	8.7
eta Lep	F1V	9.2
lam Gem	A3V	11.3
bet Leo	A3V	7.0
ksi Boo	G8V	7.9
Altair	A7V	2.8
Vega	A0V	2.8
110 Her	F6V	9.6
Zet Aql	A0V	11.0
alf Cep	A7IV	6.0

Hot Excesses Due to Magnetic Trapping of Nanograins

- Sublimation of micron-sized grains deposits population of nanograins (Mann et al. 2006)
  - Circumvent strongest effects of blowout because parent grains are too large and daughters too small
- Nanograins acquire significant electrical charge (Pedersen & Gomez de Castro 2011)
- Even with weak stellar magnetic fields (1 Gauss) the magnetic force captures electrically charged nanograins on epicyclic orbits
- Such fields are expected even for A-stars (e.g., Lignieres et al. 2009 for Vega)
- Collisions are dominant loss mechanism, but lifetimes can be months to a year (Rieke & Gaspar, to be submitted to ApJ)



Typical grain orbit



Grain lifetimes against collisions

Key questions

1. Is it real?
2. If so, is it dust? What are the alternatives?
3. What are the dust and population properties?
   - Spatial information – location, geometry
   - Spectral information – T, spectral features, emission mechanism (thermal vs Scattered)
   - Combined with Modelling: grain size, composition
   - Luminosity distribution
4. What comet/gas/dust physics do we need?
   - Can we test the phenomenological models?
   - Can we connect to the solar system? (dust properties, stardust results + stargazing comets)
5. What are the dust lifetime/fate/origin?
   - Dependence on stellar properties
6. Does it affect exo-Earth imaging in the visible?
   - Produces visible brightness in the HZ
   - Produces coronagraph leakage

Is it real? i.e. are the visibility deficits astrophysical?

Work Required to Answer Question	Already Done?	Already Planned?	Priority
Observational: O1 hammer on the 3-5 large excess stars to test repeatability/variability O2 confirmed with a completely different technique (IRTF, spectroscopy) O3 observe only A stars @ CHARA to test systematic variability (measure spectral slopes) O4 observe known binaries with contrast at the 1% level (measure position with MIRC) O5 Show the excess distribution for calibrators only	some obs already eps Cep	y - CHARA, PIONIER need targets, 'clean' A cals do w/ CHARA PIONIER	y y y
Theoretical: T1 Test correlation between excess variability and astrophysical periodicities T2 T3 ...		n - confirm first	

If real, is it dust?

Work Required to Answer Question	Already Done?	Already Planned?	Priority
Observational: O1 Follow up FLUOR binary detections with MIRC O2 Search for wide companions with an imaging instrument O3 Observe spectral features to prove it's dust O4 FGS observations of largest systems O5 Revised the full beta Pic data set and try to constrain the geometry O6 Document parameter space probed by CP	NaCo+ 4% Olivine dip in eta Crv dust (0.9-1.4um) MIDI - to be analysed bg obj done	y - need obs time n-SPHERE IRTF n-feasibility n-need person time revisit - L. Marion	
Theoretical: T1 Can somebody make predictions from stellar models for early-type/late type stars? (any open code?) T2 NIR excess expected at other evolutionary stages? evolved stars? T3 ...	free-free emission is excluded	n - need help n - need help need interest of stellar people - Aufdenberg?	

What are the dust properties?

Work Required to Answer Question	Already Done?	Already Planned?	Priority
Observational: O1 Observe at very short baselines (4-8m, PFN, NRM) to constrain excess geometry O2 Coordinated observations: GRAVITY+PIONIER (H&K) CHARA-PIONIER CHARA-IRTF O3 JWST imaging down to >1AU but not much better than Spitzer. Aperture masking better than 10^-4 contrast Gaia?		PFN run in June 2015 check V2 accuracy of NRM PFN run to be coordinated with CHARA run, also PIONIER (as close as possible if really variable) n - relies on O1	
Theoretical: T1 Need to test more optical constants Most refractory, highest albedo dust: olivine, metal oxide, peroxide, nano-phase iron, pure magnesium olivine What does nanodust look like? (see e.g. Stardust) T2 Can we make predictions? What should we observe? (build-up SED e.g. in the visible, optical features e.g. Olivine 1μm + sublimation distances) T3 Make PR models: expect they are not time variable T4 Test 3D models (optically thick?)	n	literature, rule out very blue dust? n - want timescale estimates n - needed	

Does the NIR dust affect exo-Earth imaging in the visible?

Work Required to Answer Question	Already Done?	Already Planned?	Priority
Observational: O1 - Short baseline observations - LBTI? Aperture masking? New scopes for existing interferometer? O2: Polarised visible coronography (SPHERE) O3: ...			
Theoretical: T1: Quantify dust color from new keck results T2: does a species exist that can sit in HZ, not emit at mid-IR and scatter at NIR? T3: Simulate a hot ring at the sublimation radius: is it a problem for coronagraphs? ...			

How much of a problem is the NIR excess phenomenon for future exo-Earth imaging missions?

- Where is the NIR excess source located?
  - Measure its spatial brightness distribution in the NIR
  - Establish whether or not it comes from dust in the HZ
- What is its wavelength dependence?
- What is its stellar spectral type dependence?
- Is it thermal emission or scattering, or both?
  - So we can more easily extrapolate to the visible
- Are NIR surveys a mandatory complement to MIR surveys?
- If NIR excess not coming from HZ, can it still tell us about dust in the HZ?

What comet/gas/dust physics do we need?

Work Required to Answer Question	Already Done?	Already Planned?	Priority
Observational: O1 Polarimetric observations ppm level, worthless if unresolved obs a non-det O2 Assess variability. make “known truth” observations every run to believe variability. O3 Look for FEBs ...		O1: VLT/SPHERE, Subaru/Vampires ongoing O3: hires spectro follow-up of hot exozodi submitted (PI: Eiroa)	
Theoretical: T1 Figure what the removal timescales really are T2 Can there be nanodust with beta < 0.5 T3 Model gas production & dispersal (=>G/D ~1 ?)	y-but Mie etc.	summarise for scenarios	

Dust origin/lifetime/fate

Work Required to Answer Question	Already Done?	Already Planned?	Priority
Observational: O1 Observe stars with small, inner planets O2 Measure stellar activity (X, wind) O3 Observe stars with known magnetic field ...			
Theoretical: T1 What happens to the dust at the final stage, can we see the leftover? T2 Make predictions from comet delivery models (e.g. mid-ir), compare with Solar System, and PR predictions T3 Get complete picture of system architecture on a case-by-case basis to compare with numerical models T4 HD69830. Why don't we detect near-IR excess ? (given the HUGE MIR excess just 1AU away ...) -> Good case for T3! T5 Compare to polluted white dwarfs T6 Dust in the F-corona, beta meteoroids T7 Magnetic trapping	Marboeuf+12 (T2) in progress (T7)	sims in progress (T3) n - n-body needed (T4)	