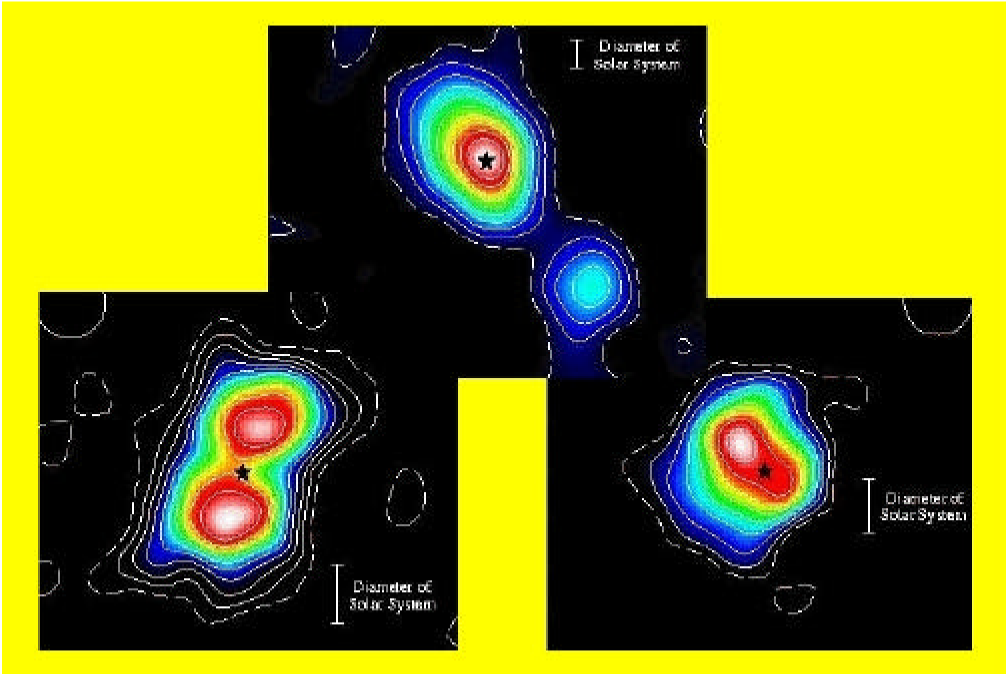
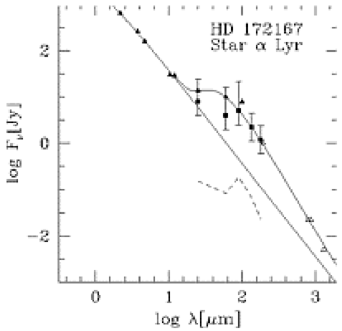
Debris Disks with PACS/SPIRE

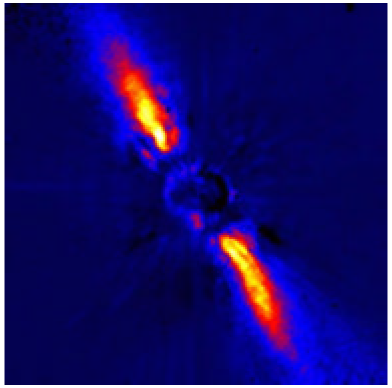


Christoffel Waelkens

Astrocam meeting, Madrid, 14-15 December 2006

What are debris disks?





QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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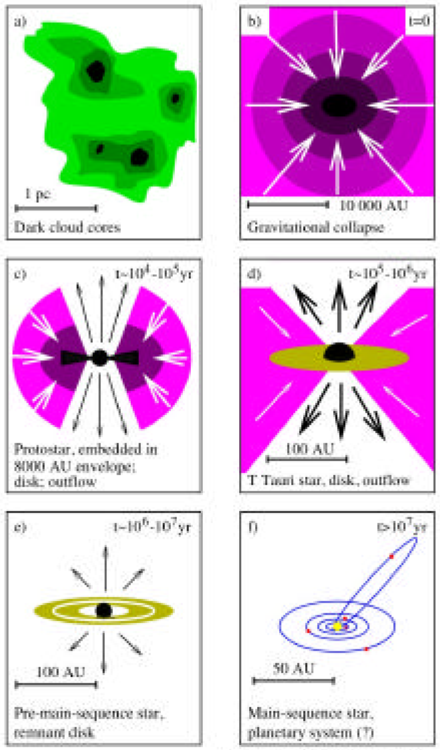
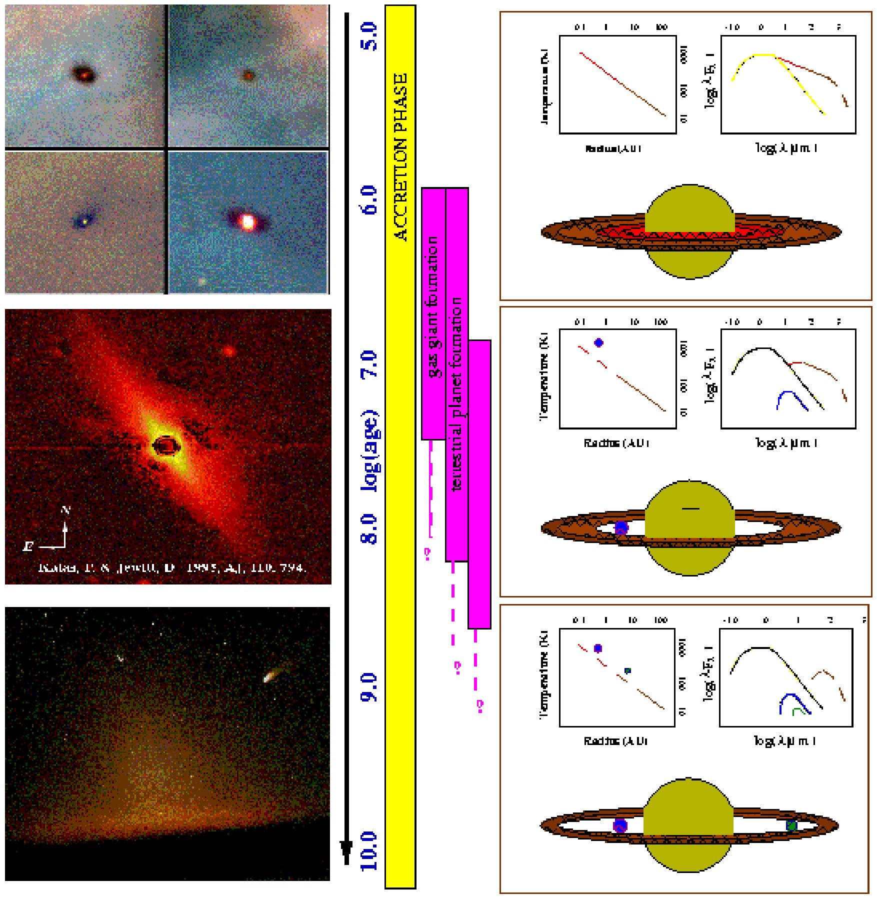
- Mature stars with dusty disks
- Disks must be replenished by collisions
- How do they relate to exoplanet systems?

Disk evolution



Hogerheijde 1998, after Shu et al. 1987



Who is involved?

HSC	G. Pilbratt et al. (ESTEC, ESAC)	(70 hrs)
MS	P. Harvey (U. Texas, US)	(30 hrs)
SPIRE	G. Olofsson, R. Liseau (Stockholm, S) M. Barlow, H. Walker, T. Lim, S. Eales, R. Ivison (UK) J. Di Francisco (Canada), M. Cohen (US)	(70 hrs)
PACS	J. Blommaert, P. Royer, B. Vandenbussche, CW (B) E. Pantin (Paris, F) J. Bouwman, T. Henning (MPIA, D)	(70 hrs)

Some Spitzer results

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Herschel versus other tools

Specific advantages of Herschel

- probes the 'most relevant' wavelength range
- largest telescope in space: angular resolution

Programmes which exploit these advantages

- completing SEDs of known samples
- search for coolest debris disks
- imaging substructures in the disks
- (spatially resolved) spectral studies

The Spitzer sample

Age	N_* / N_{tot}	Distance (pc)	Target
3-10 Myr	50/ ~140	80-160	Tau, Oph, Cha, Lup, Upper Sco
10-30 Myr	50/ ~110	60-160	Tau, Oph, Cha, Lup, Cen Crux
30-100 Myr	50/ ~130	40-180	IC 2602 & Alpha Per
100-300 Myr	50/ ~100	20-120	Ursa Major, Castor, Pleiades
0.3-1 Gyr	50/ ~1000	20-60	Field stars, Hyades
1-3 Gyr	50/ ~1000	20-60	Field stars

SED studies with Herschel

- Evolution of excesses: studying SEDs as a function of age
- Investigating the occurrence of very cool excesses in objects for which no Spitzer excesses have been found
- Probing ‘zodiacal’ excesses of nearby stars (Darwin?)

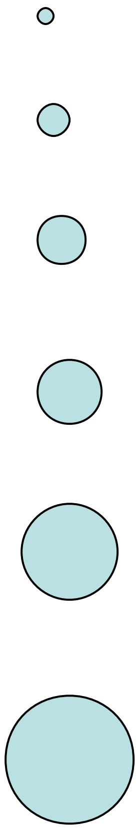
Sun + Kuiper belt seen from a certain distance

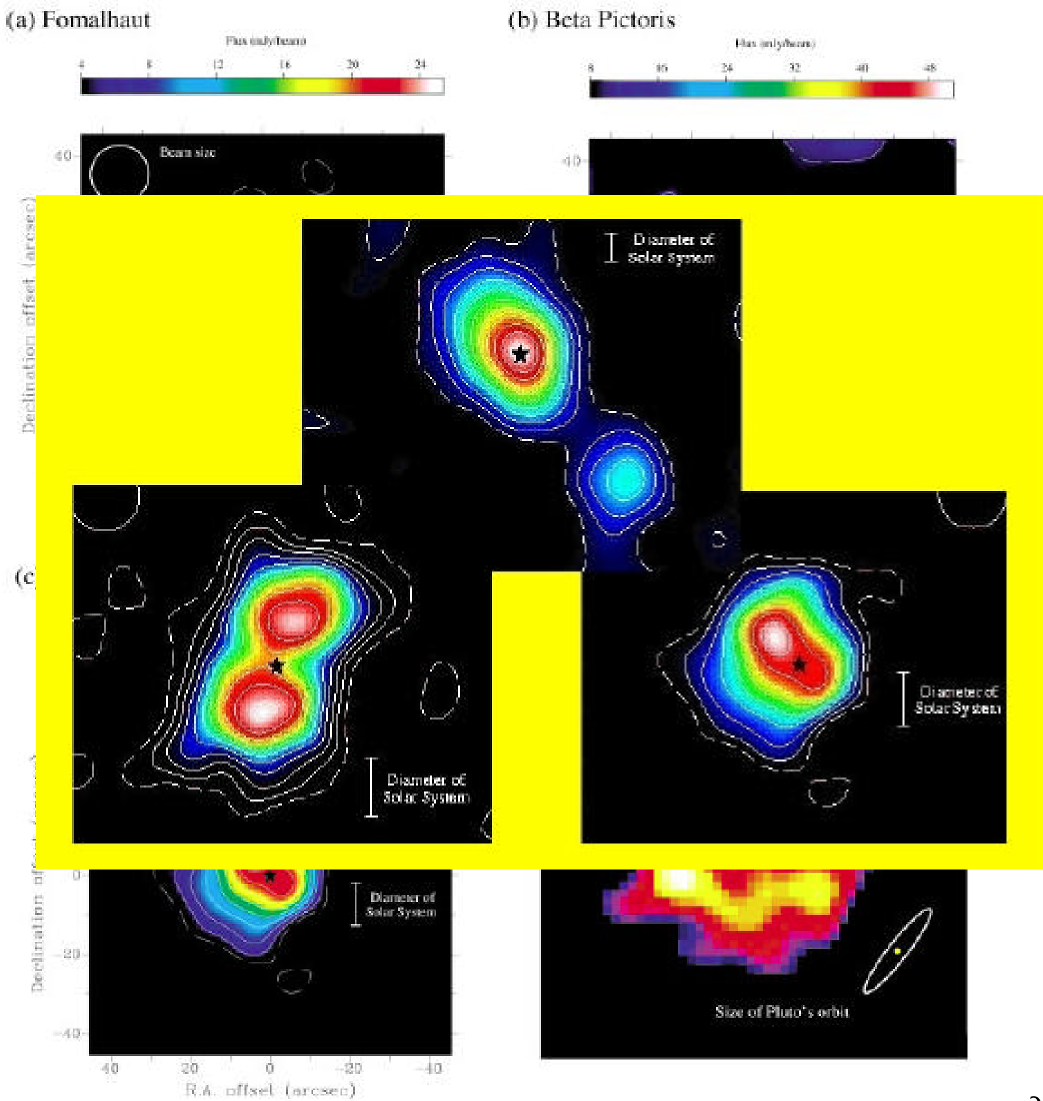
Wavelength	10 pc	20pc	Ldust/Lsun
70	0.004	0.001Jy	0.04
100	0.007	0.002	0.17
130	0.008	0.002	0.27

Nearby stars, sample

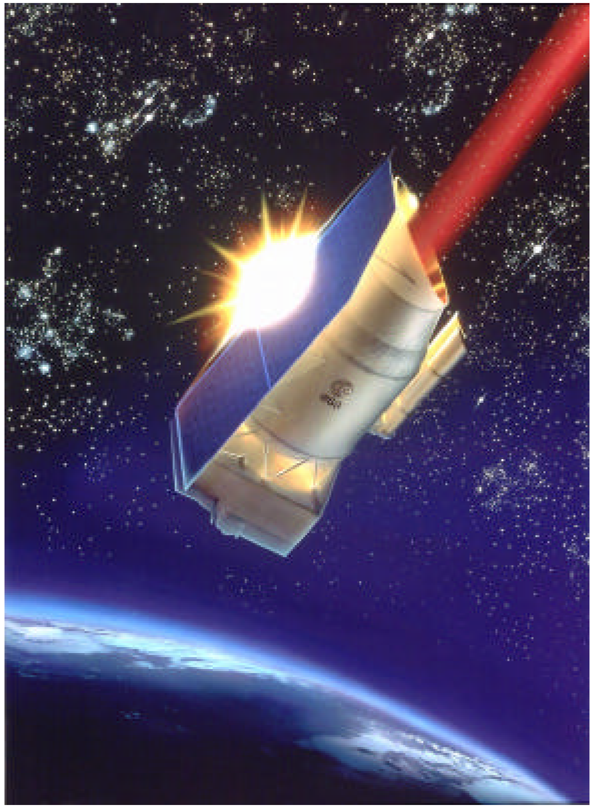
Distances according to spectral type						
distance	F,G,K,M	F,G,K	F	G	K	M
0-5 [pc]	10	1	0	0	1	9
5-10 [pc]	34	7	0	2	5	27
10-15 [pc]	97	42	3	10	29	55
15-20 [pc]	133	86	11	23	52	47
20-25 [pc]	171	126	15	34	77	45
sum	**445**	**262**	**29**	**69**	**164**	**183**

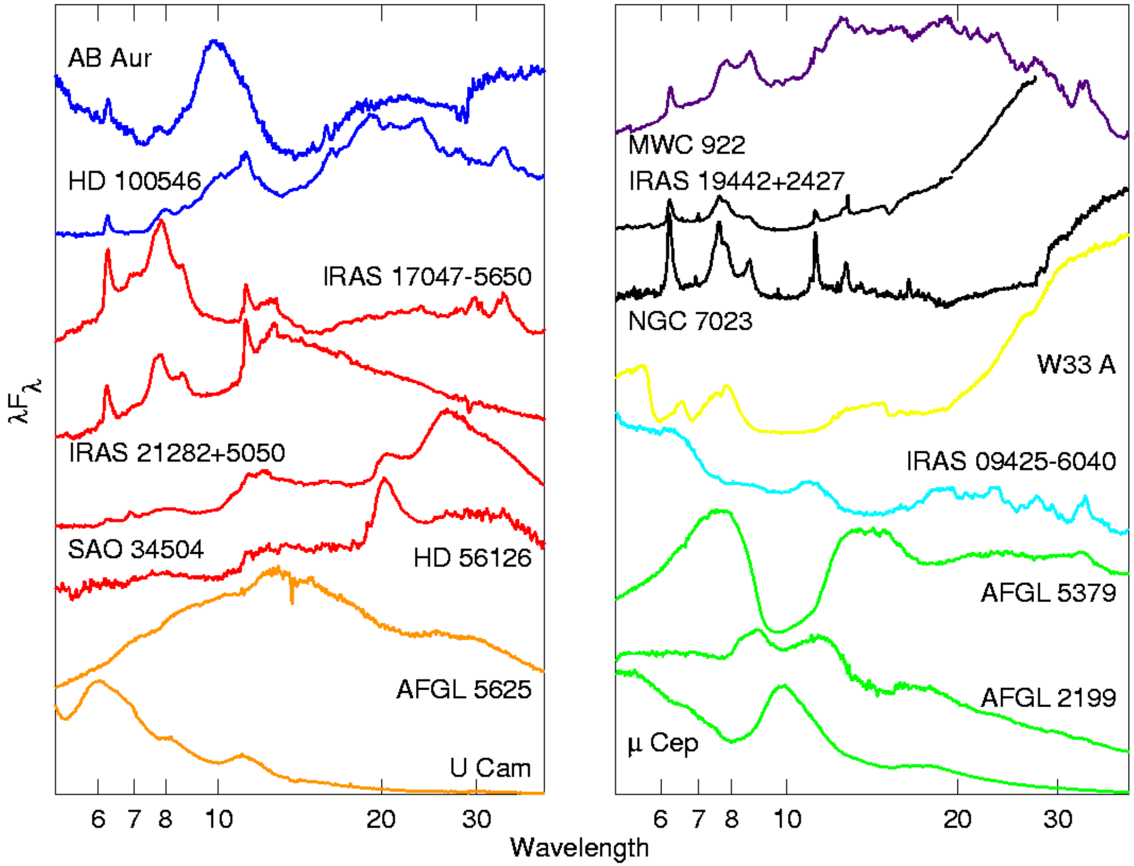
Spatial resolution



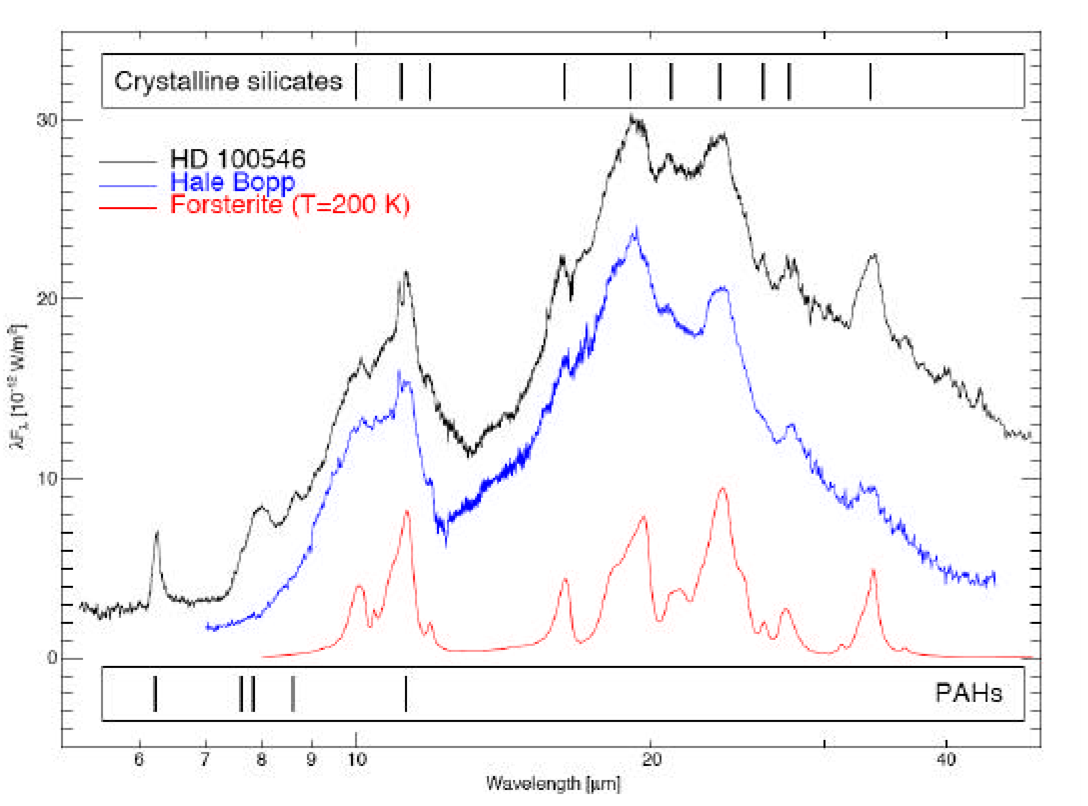


Dust diagnostics in circumstellar media





Link between CS disks and comets



Which solid-state diagnostics are to be expected in the PACS-SPIRE range?

- Spectral range is not obviously optimal with respect to known features (starts on ice feature, 10-50 μm range richer than longer λ one).
- Debris disks are rather featureless.

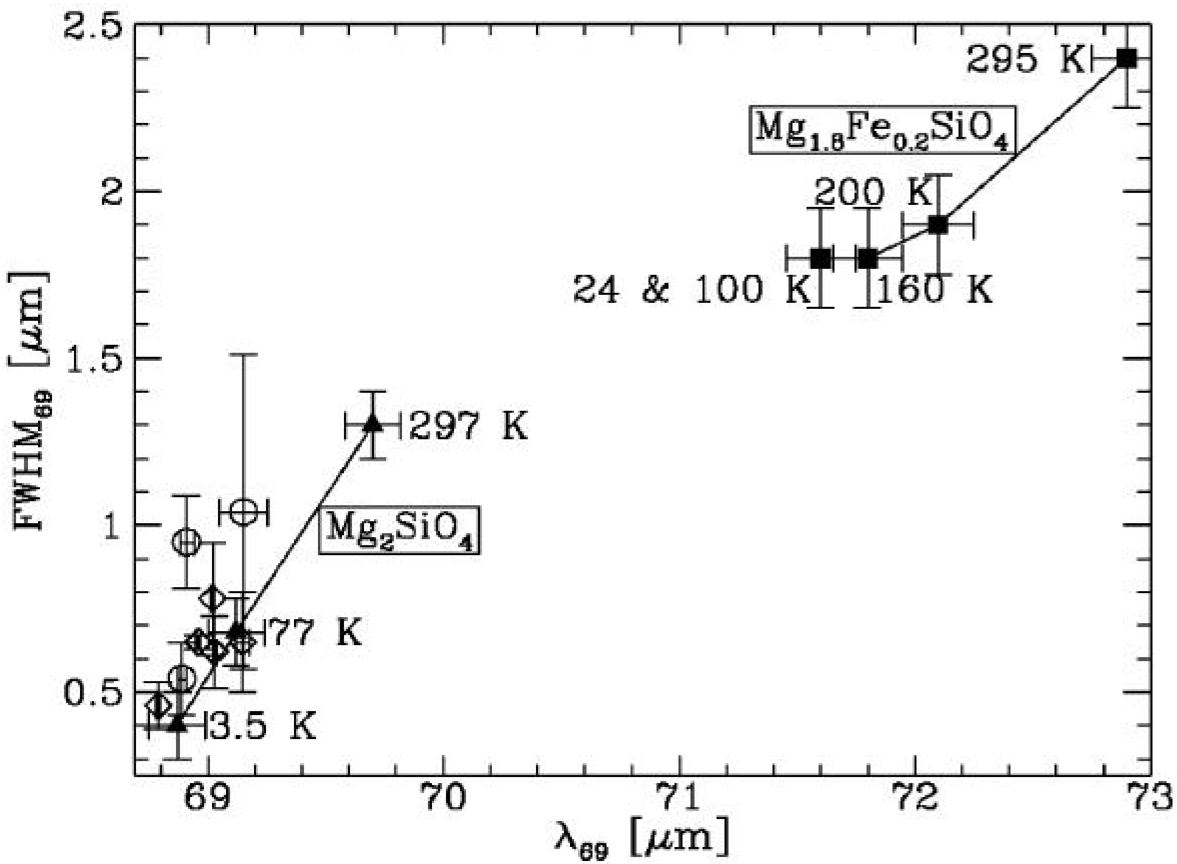
But

- There are some interesting issues (see below).
- It makes sense to be open for the unanticipated, certainly so in the framework of a GT programme.
- Mineralogy is important to link debris disks to younger CS disks, and star- and planet formation in general.

The 69 μm band

Science

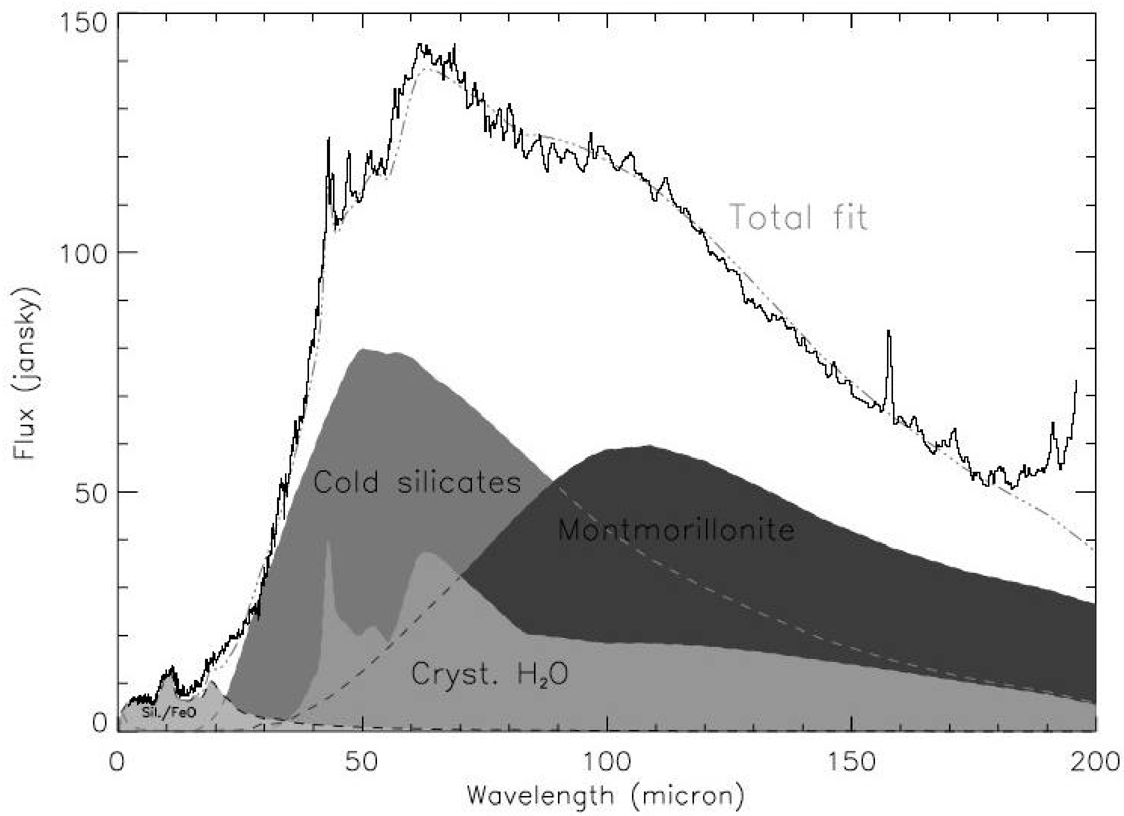
- Composition
- Temperature



References:

- Koike et al, 2000, AA, 363, 1115
- Molster et al, 2002, AA, 382, 241

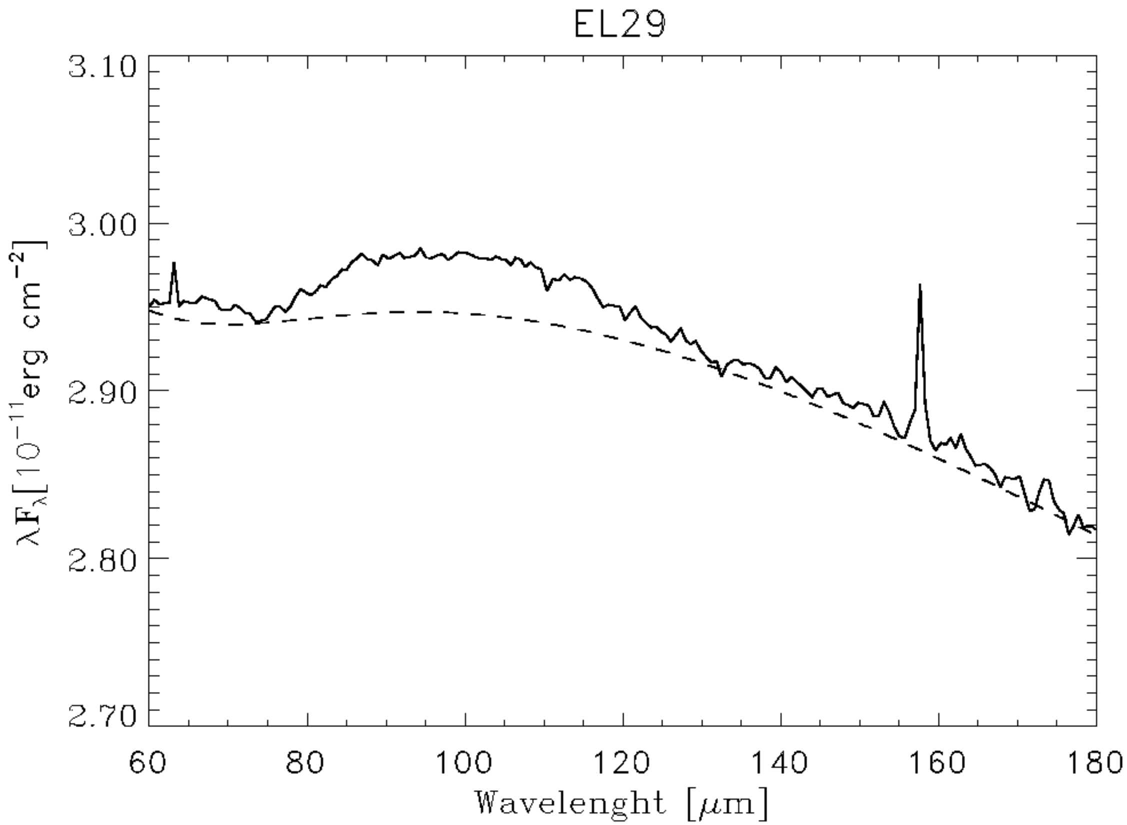
Hydrated Silicates



The 90 μm Feature

Characteristics

- 90-100 μm feature
- Varies in peak position and width

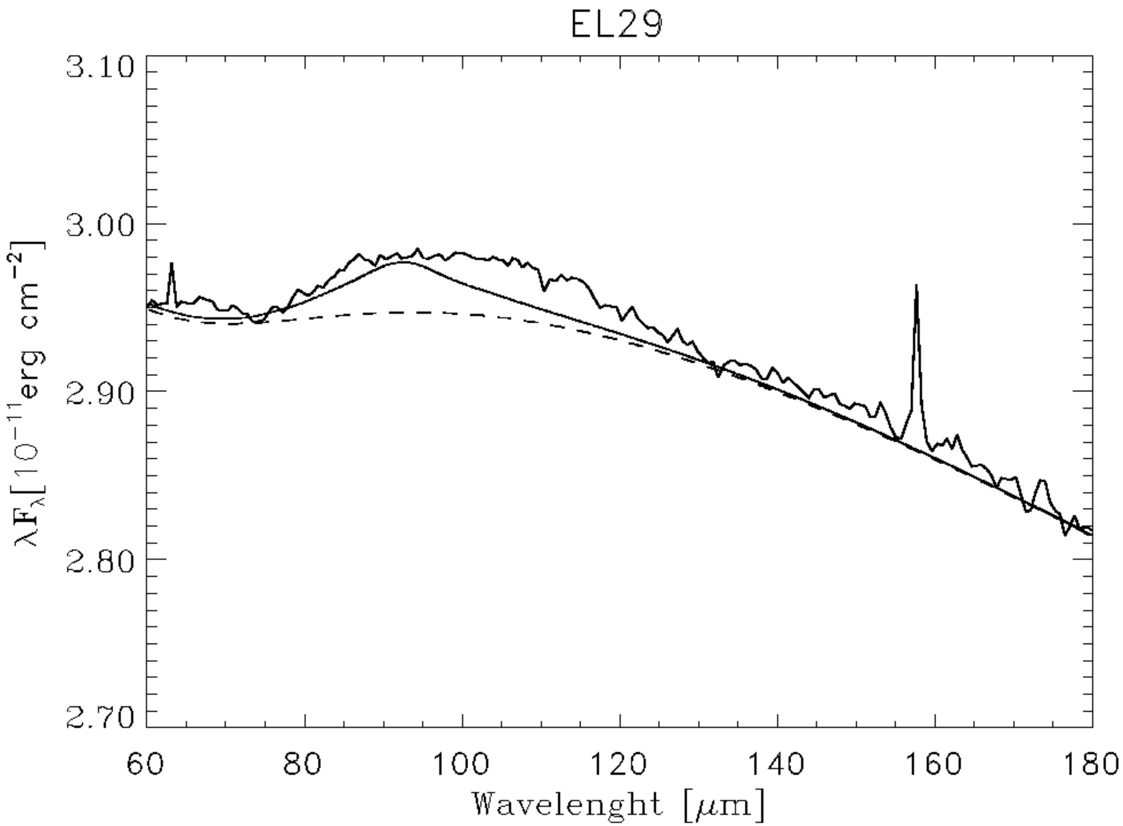


References:
Kemper et al.. 2002, AA, 679, 690
Ceccarelli et al. 2000, AA, 362, 1122
Onaka and Okada, 2003, ApJ872, 877
Chiavassa et al, 2004, AA, subm

The 90 μm Feature

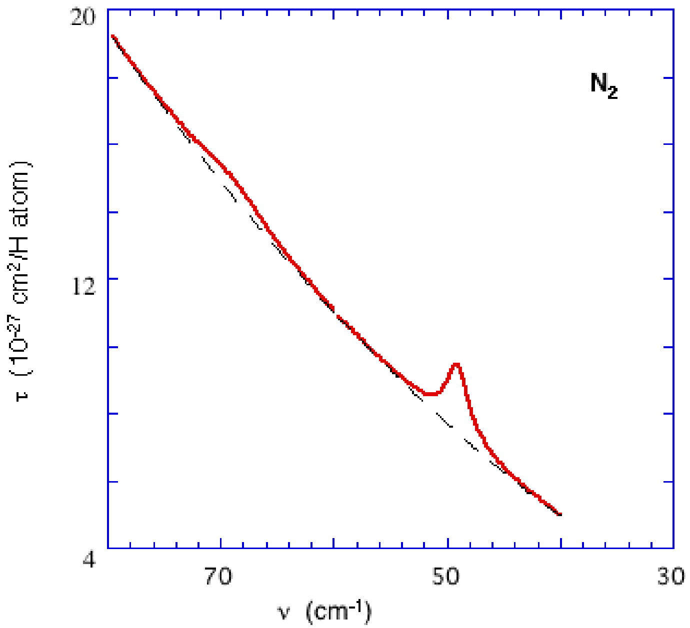
Proposed identifications

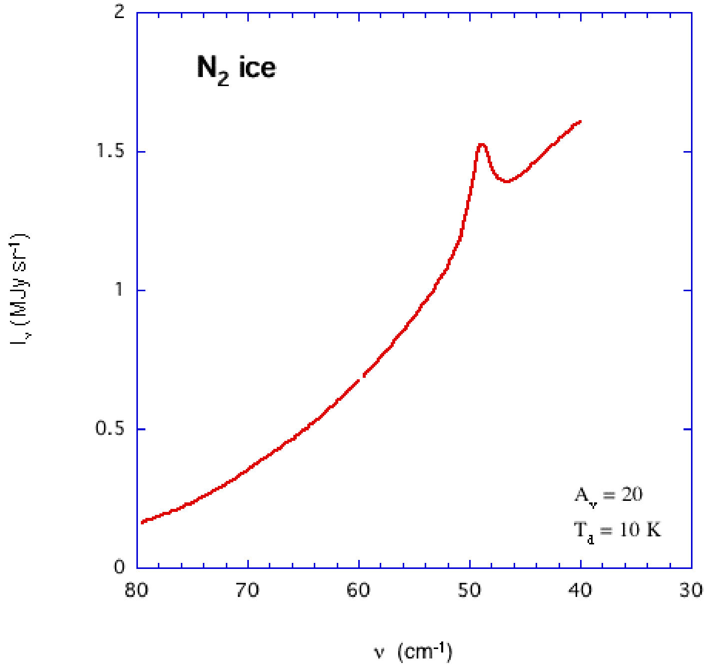
- Calcite
- Carbon onions



On Earth, calcite is a product of weathering of minerals in a water/CO_2 solution

Far-IR Phonon Modes





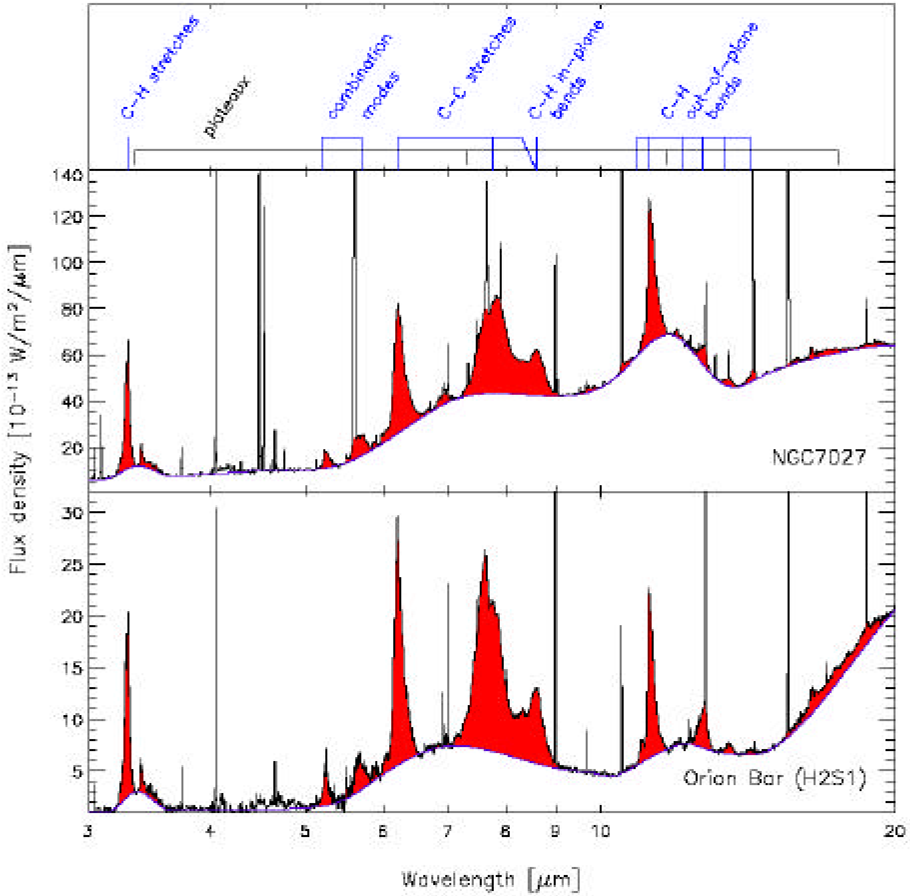
Direct way to detect homonuclear ice species

N_2: 69 and 49 cm^{-1}

The Rich mid-IR Spectrum of Interstellar PAHs

Characteristics

- A multitude of bands due to vibrational modes of PAHs
- Mid-IR bands: characteristic for molecular groups not molecular species

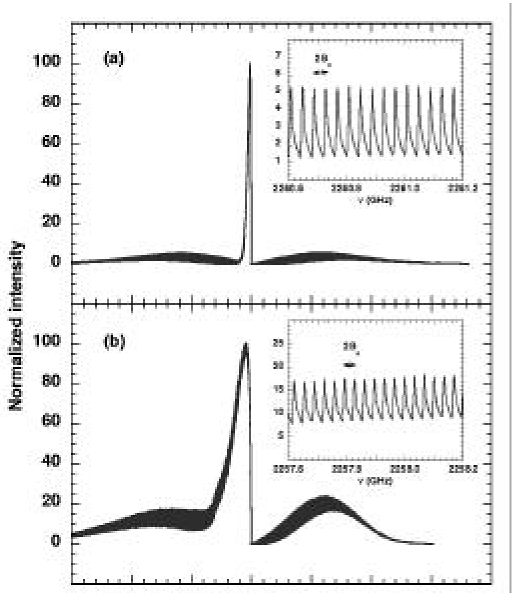


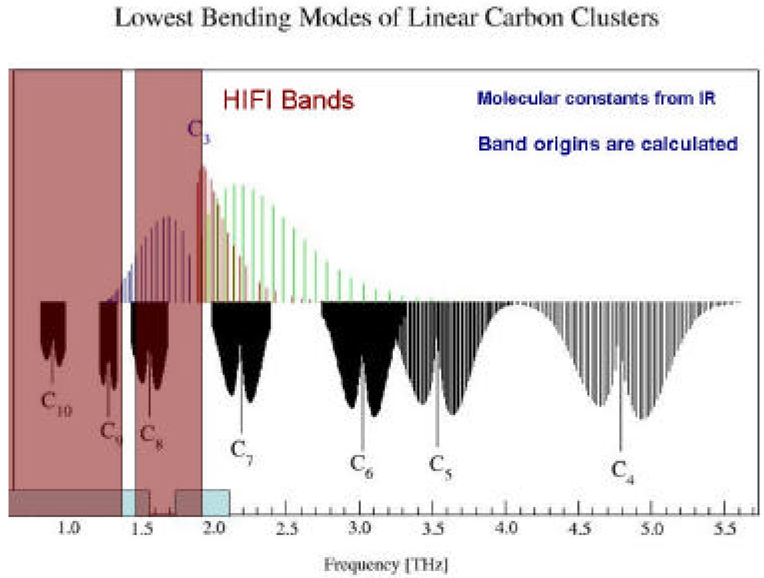
Reference:

Peeters et al., 2002,

AA, 390, 1089

Low Frequency Ro-Vibrational Modes





Characteristics

- Low internal energies
- Ro-vibrational bands
- Molecule specific

Reference: Joblin et al., 2002, Mol Phys, 22, 3595; Giesen et al, private communication

Time distribution

Theme	*PACS*	*SPIRE*	*Total*
Disk evolution	*22*	*18*	*40*
Nearby stars	*60*	*11*	*71*
Big five	*25*	*10*	*35*
Spectroscopy	*59*	*26*	*85*
SUM	*166*	*65*	*231h*