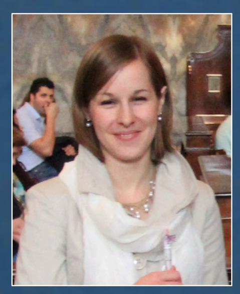
miotello@mpe.mpg.de



Grain growth in the envelopes of Class I protostars

A. Miotello[1,2,3,4], L. Testi[1,5,6], G. Lodato[2], L. Ricci[7], G. Rosotti[3,5], K. Brooks[8], A. Maury[9], A. Natta[6,10]

[1] European Southern Observatory, [2] University of Milan, [3] MPE Garching, [4] Leiden Observatory, [5] Excellence Cluster Universe, [6] INAF-Arcetri, [7] CALTECH, [8] ATNF, [9] CfA, [10] DIAS

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Many observational results (Testi et al. PPVI review) indicate that the vast majority of the protoplanetary disks in the Class II phase contain mm- and cm-sized grains. This implies that the formation of these large particles is a fast process that occurs in the early stages of disks or possibly even earlyer. Pagani et al. (2011) have shown that micron-sized grains are already present in prestellar cores, while mm-sized particles may have been detected in Class 0 YSOs envelopes (Chiang et al. 2012).

GOAL

The aim of this work is to constrain the level of grain growth in Class I YSOs, where the contribution of the envelope emission can be separated by the disk one, using mm-interferometry.

RESULTS

- mm-sized pebbles in the envelopes
- Very compact embedded disks

Analysis

- Fig. 1 and 3: visibilty amplitudes of Elias29 and WL12: with archival 1.1 mm SMA data (Jørgensen et al. 2009) and new 3 mm ATCA dataset.
- Emission rises at the shortest baselines: presence of an envelope
- Emission at the long baselines converge to a constant non-zero value: presence of an unresolved embedded disk.
- Under the optically thin assumption and the Rayleigh-Jeans approximation: unusually low α, for both disk and envelope.

➡ Modeling of the disk and envelope structures, using radiative transfer codes, is needed.

Disk modeling

- Two-layer disk model (Dullemond et al. 2001). Free parameters: disk outer radius *Rout*, mass *Mdisk* and the grains maximum size *amax* .

Envelope modeling

- Rotating and collapsing envelope model as derived by Ulrich et al. 1976.
- Envelope temperature structure computed using the Monte Carlo radiative transfer code RADMC-3D (Dullemond & Dominik 2004). Central heating source star+disk.
- Envelope mass *Menv* and *amax* left free to vary.

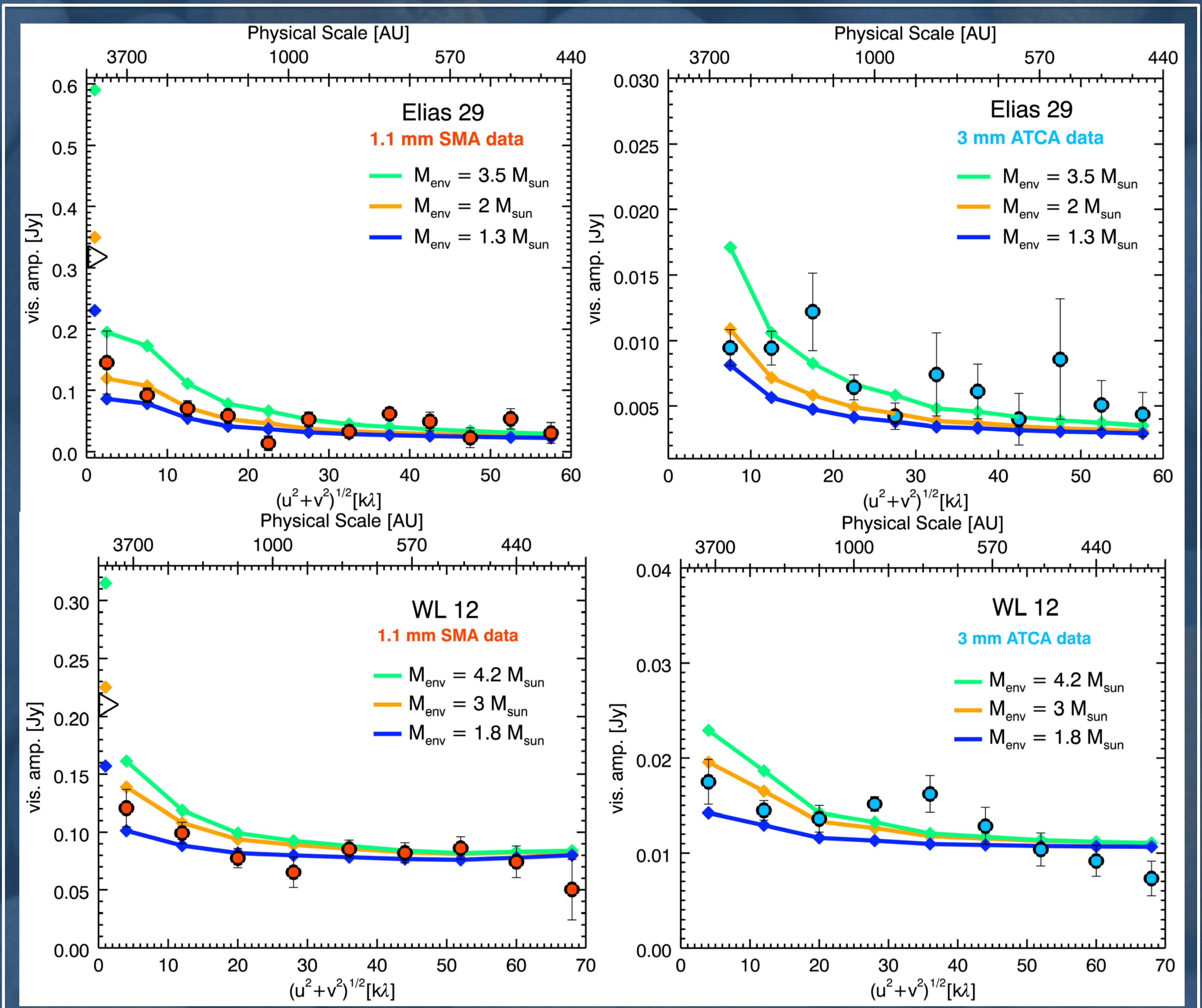
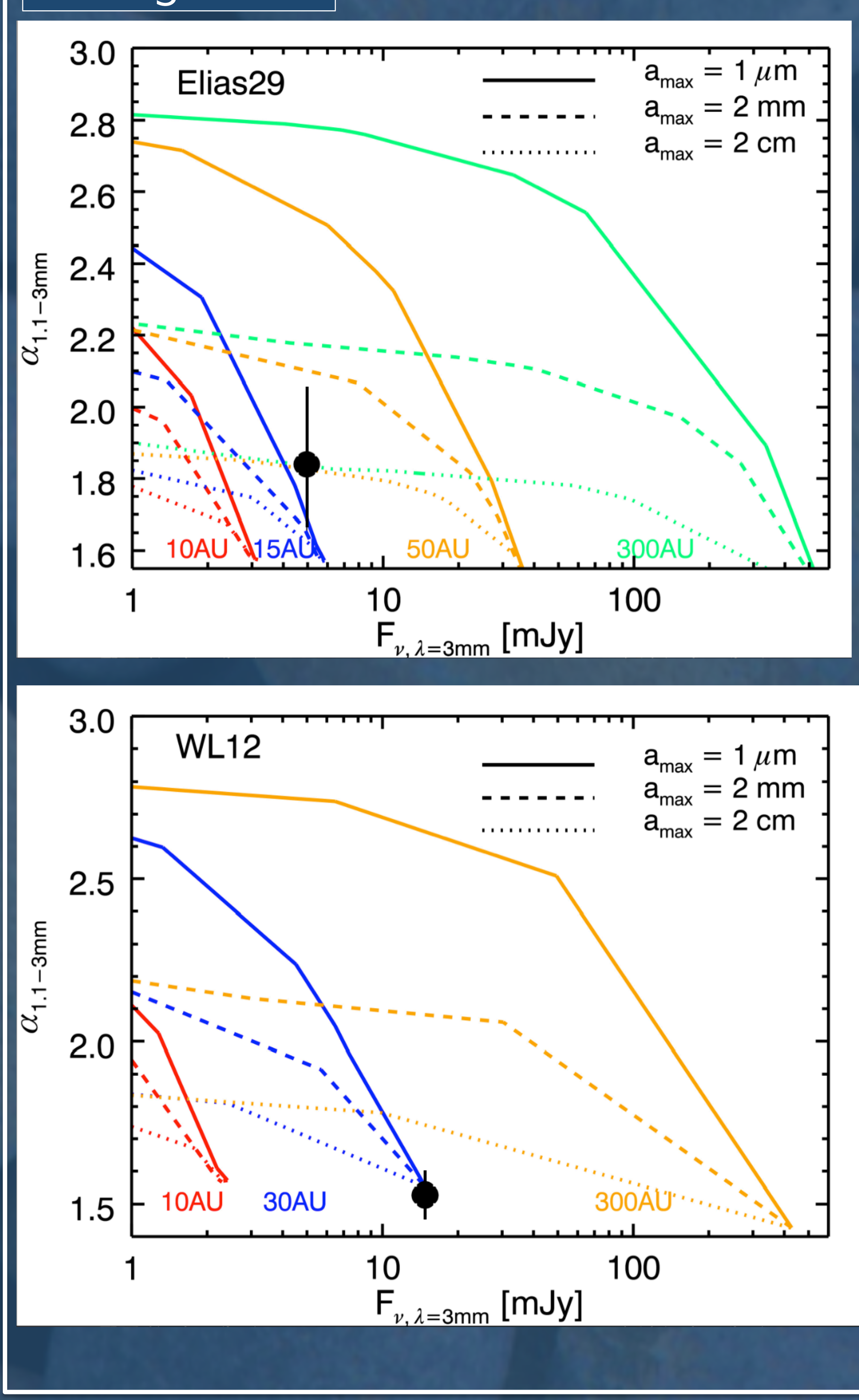


Fig. 1 Visibility amplitudes. The data points give the amplitudes per bin. Amplitudes of Elias 29 (top panels) and WL12 (bottom panels): on the left, archival 1.1 mm SMA dataset (Jørgensen et al. 2009), on the right new 3 mm ATCA dataset. The open triangles: zero spacing 1.1 mm fluxes, interpolated between 850 μm and 1.25 mm single dish fluxes (Lommen et al. 2008; Jørgensen et al. 2009). Orange lines are the best fits, obtained using the two-layer disk model (Dullemond et al. 2001) combined with a rotating and collapsing envelope model implemented on RADMC-3D (Dullemond & Dominik 2004) .

Compact disks

Fig. 2



Elias 29

- Either a small optically thick disk (*Rout*~15 AU, Mdisk~0.07Msun), where we cannot constraint the dust properties,
- or a relatively large (*Rout*~50-200AU) optically thin disk populated with large pebbles.

WL12

- Compact and optically thick disk with radius *Rout*~30 AU and mass between 0.3 and 0.8 solar masses. We can not constrain the dust properties.

Big grains in the envelopes

- Micrometer-sized grains do not explain the observations both at 1mm and 3 mm, while mm-sized ones do (Fig.3).

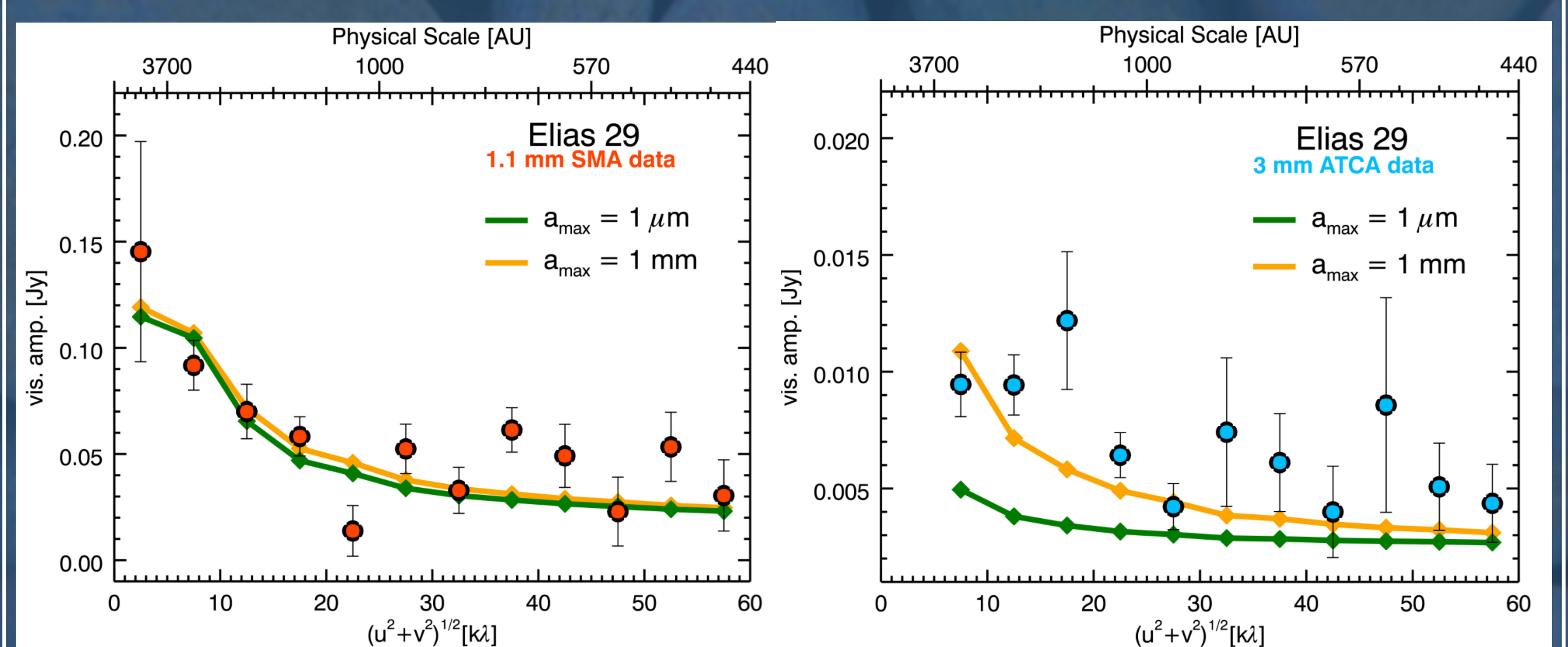


Fig. 3

REFERENCES: Chiang et al. 2012, ApJ, 490, 368 • Dullemond et al. 2001, ApJ, 560, 957 • Dullemond & Dominik 2004, A&A, 417, 159 • Jørgensen et al. 2009, A&A, 507, 861 • Lommen et al. 2008, A&A 481, 141 • Pagani et al. 2011, EAS, 52, 225 • Ricci et al. 2010, A&A, 521, A66