National Aeronautics and Space Administration

Vertical extent of mm-sized dust in the young disk around IRAS04302

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Introduction / Context

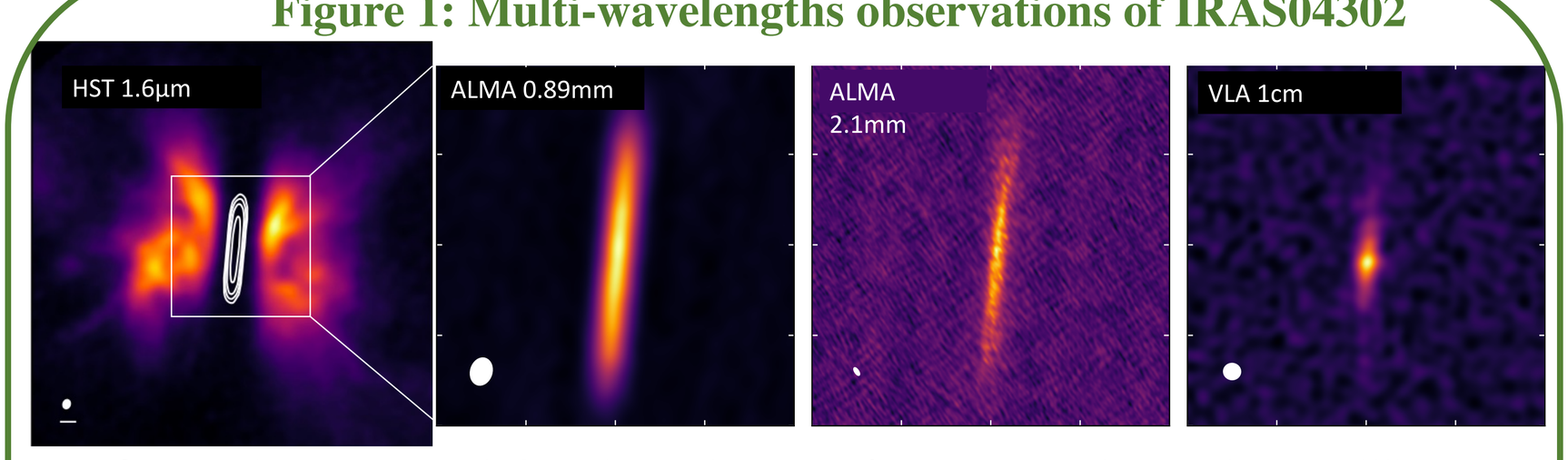
- Observed disk lifetime of protoplanetary disks conflicts with the planet formation timescale of current theories.

- Vertical settling can concentrate dust in geometrically thin regions, which is favorable for faster grain growth and planet formation.

Aims of this study: **Constraining vertical settling in a young disk to better understand the efficiency of planet formation.**

Target: IRAS04302+2247
Age: 1-2 Million years, M_{star}: 1.7M_{sun}

Figure 1: Multi-wavelengths observations of IRAS04302



Left: HST image at near infrared wavelength, **Middle**: ALMA images in the millimeter, **Right**: VLA observations at centimeter wavelengths

- HST image (left panel): sensitive to ~μm sized dust particles, shows an envelope
- ALMA and VLA images: probe dust grains of mm sizes, affected by vertical settling.

- HST image: more extended than the ALMA and VLA observations (other panels).
- ALMA 2.1mm image: well resolved in the minor axis direction, which allows to get strong constraints on its vertical extent.

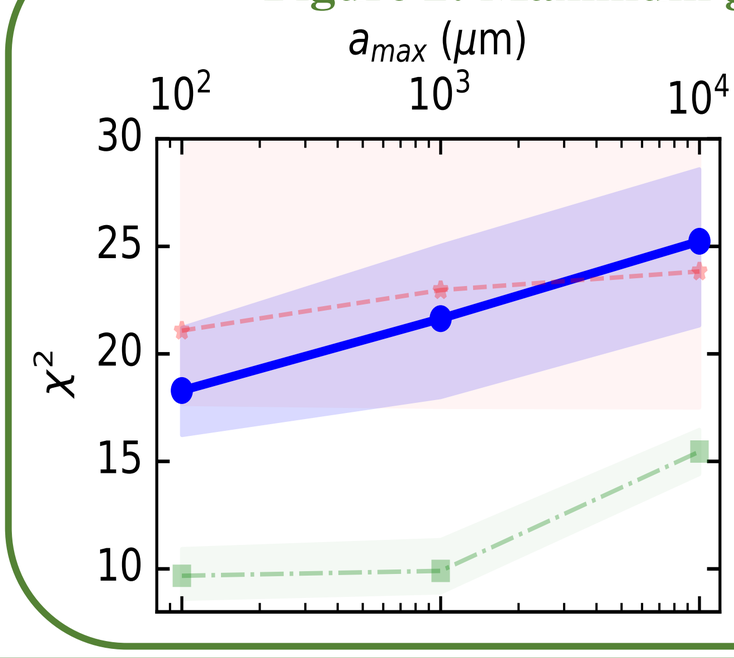
Modeling approach

We model the ALMA and VLA images together using the radiative transfer code MCFOST [1, 2] and a grid approach.

Table 1: Grid parameters

Parameter	Values
Dust Height at 100au from the star	1, 3, 4, 5, 6 au
Inclination	88, 89, 90 deg
Maximum grain size	100, 1000, 10000 μm
Dust mass	10^{-5} to 10^{-3} M_{sun}

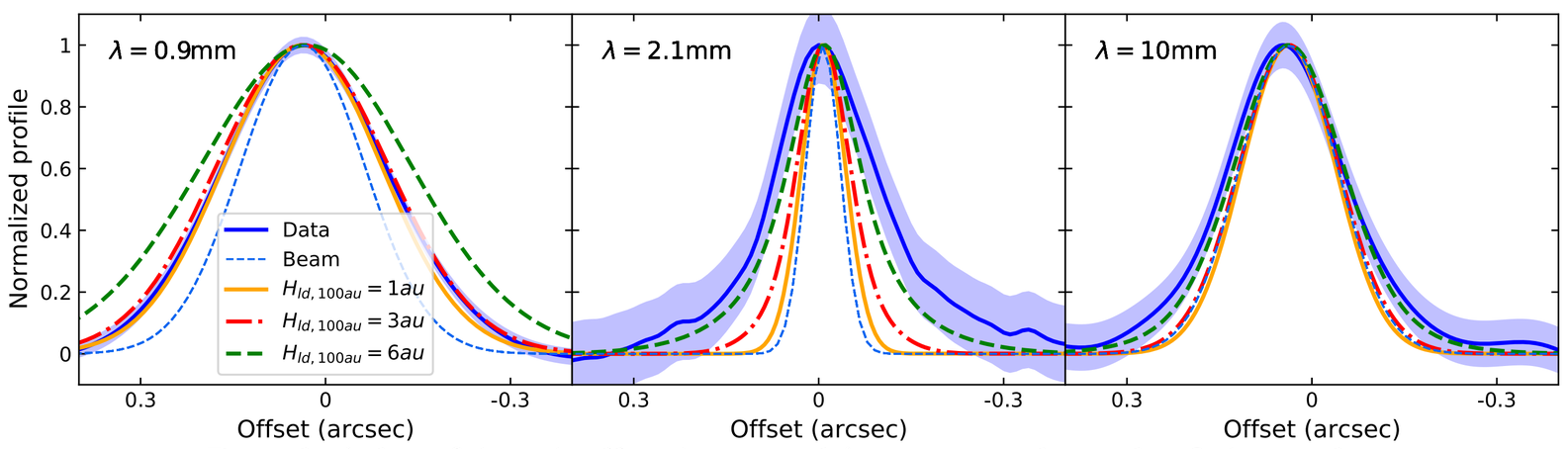
Figure 2: Maximum grain size < 1cm



Larger a_{max} imply poorer fit (higher χ^2)

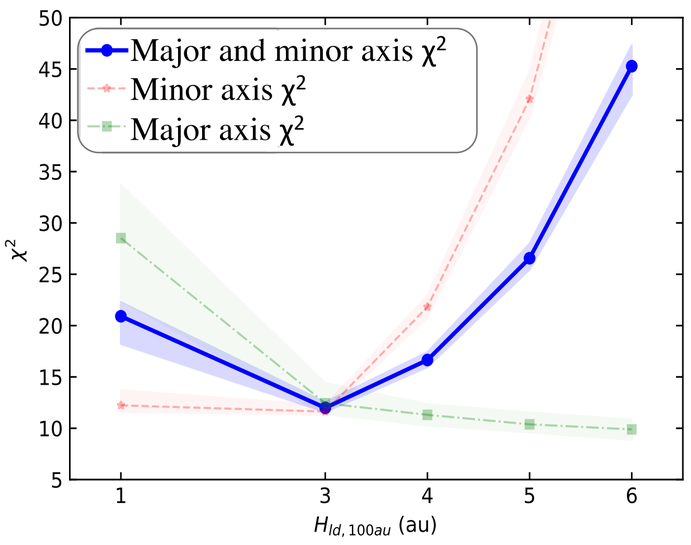
Optical depth is enough to explain the smaller size at cm (VLA) compared to mm (ALMA) wavelengths

Figure 3: Effect of dust height on averaged minor axis profiles



Dust height of 1au (yellow) – too thin to reproduce the 2.1mm data
Dust height of 6au (green) – too thick to reproduce the 0.9mm data
Best compromise = dust height of 3au (red), see Figure 4.

Figure 4: Best dust scale height ~3au at 100 au from the star



Dust height is between 1au and 6au at 100au from the central star. Contrary to more evolved disks where dust height <1au, IRAS04302 is subject to modest settling only (gas scale height ~7au), possibly due to higher turbulence in this younger evolutionary stage.

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References:

Villenave et al. in prep
[1] Pinte et al. 2006, A&A, 459, 797
[2] Pinte et al. 2009, A&A, 498, 967

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Abbreviations:

- **HST**: Hubble Space Telescope, observing at optical and near-infrared wavelengths.
- **ALMA**: Atacama Large Millimeter Array. Radio telescope located in Chile, observing in the mm.
- **VLA**: Very Large array, observing in the cm.
- **au**: Astronomical unit, distance Earth-Sun.