Warm gas in the inner 20 au of the transition disk around HD 169142

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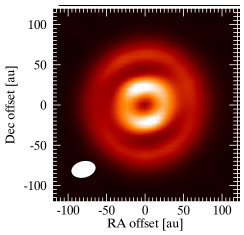
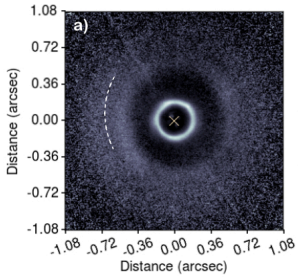
1. Introduction: the HD 169142 disk



ALMA, 1.3 mm
(Fedele+ 2017)



SPHERE/ZIMPOL
(Bertrang+ 2017)

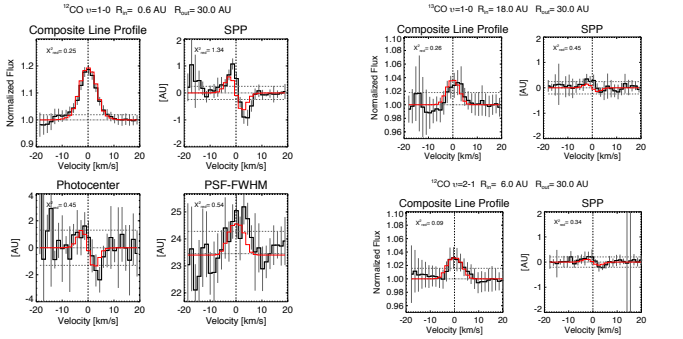
- ★ Herbig A5Ve star (1.7 Msun, d=117pc, 8.5 Myr)
- ★ ALMA 1.3 continuum + CO isotopologs (Fedele+ 2017):
  - **double ringed continuum** (20-35 and 56-83 au).
  - **gas density drop at R< 56 au**
- ★ Scattered light imaging
  - **dusty ring at 20 au** (Quanz+ 2013, NACO)
  - faint gap at 82-85 au (Pohl+ 2017, SPHERE)
  - structure inside the 20 au ring (Bertrang+ 2017, SPHERE)

What is the gas distribution inside 20 au ?

2. New data: ESO/VLT CRIRES (R~90000) spectra of CO ro-vibrational emission at 4.7 μm

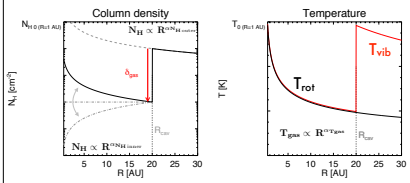
- ★ ^{12}CO v=1-0 (P6, P7, P9, P10, P12, P13, P15), ^{12}CO v=2-1 (P3, P4, P6, P7, P9) ^{13}CO v=1-0 (R2, R0, P2, P4), C^{18}O v=1-0 (R1, P1) lines detected at the stellar velocity (i.e. disk emission)
- ★ Sensitivity of the observations (1σ): 3x10^{-16} erg s^{-1} cm^{-2}
- ★ Observations used AO (PSF-FWHM = 200 mas ~ 23 au)
  - ^{12}CO v=1-0 spatially resolved, emitting region 0.5 < R < 30 au
  - ^{13}CO v=1-0 emitted at R>10 au
  - ^{12}CO v=2-1 emitted at R> 5 au

Warm CO down to 0.5 au (line wings) and least up to 30 au (spectro-astrometry)



Notes: SPP = Spread function Peak Position, **red lines: flat-Keplerian disk with a power-law intensity**

3. Gas density and temperature distribution: grid of power-law T and Σ_{gas} flat-disk models

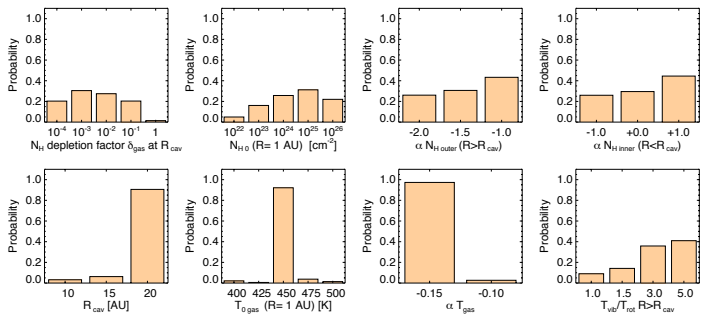


Line profiles simultaneously modeled (0.2" slit effect included)

- ★ ^{12}CO υ=1→0 P(6), P(10), P(12)
- ★ ^{12}CO υ=2→1 P(4), P(7)
- ★ ^{13}CO υ=1→0 R(2), R(0), P(2)
- ★ C^{18}O υ=1→0 R(7), R(1), P(1)

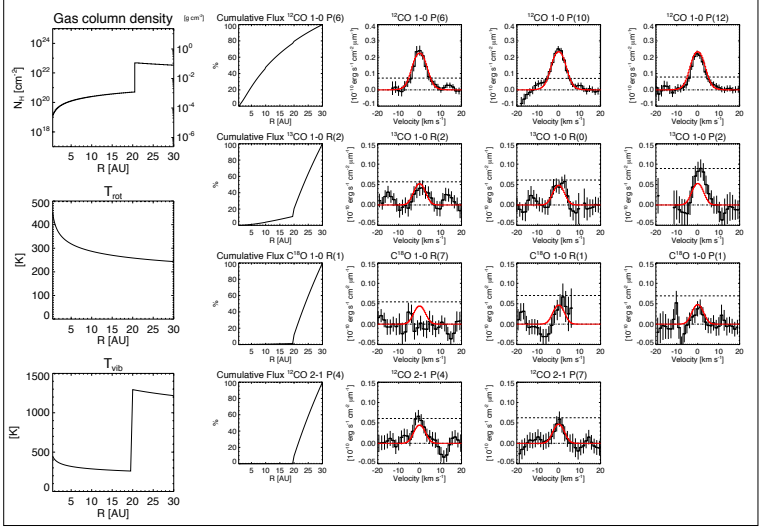
Model assumptions: LTE excitation, ^{12}CO/^{13}CO =100, ^{12}CO/C^{18}O = 690, ^{12}CO/H$_2$=10^{-4}, dust optically thin at 4.7 micron at R<20 au, **we allow T_{vib}>T_{rot} at R≥R_{cav}**

Bayesian probability diagrams of the free parameters of the grid (27000 models)

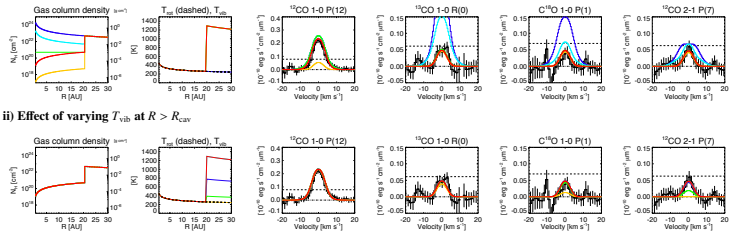


4. Grid's best fitting model

R_{cav} [au]	δ_{gas}	$N_{H\,(R=1au)}$ [cm^{-2}]	$\alpha_{NH\ inner\ (R<Rcav)}$	$\alpha_{NH\ outer\ (R>Rcav)}$	$T_{0\,(R=1au)}$ [K]	α_{Tgas}	T_{vib}/T_{rot} (R≥ Rcav)
20	10^{-2}	10^{25}	+1.0	-1.0	450	-0.15	5



5. Effects of a gas density drop and T_{vib}>T_{rot} at R_{cav}



6. Conclusions

- ★ There is warm gas down to 0.5 au inside the 20 au dusty ring.
- ★ **There is a gas density drop at R ≤ 20 au. Σ_{gas} at R ≤ 20 au needs to be 10^{-5} ≤ Σ_{gas} ≤ 10^{-3} g cm^{-2}** to describe simultaneously the ^{12}CO, ^{13}CO and C^{18}O line profiles. This column density is much lower than the extrapolated Σ_{gas} from ALMA CO observations at R>20 au.
- ★ The surface density profile at R ≤ 20 au is flat or increases with radius.
- ★ T_{vib} needs to be >1000 K (>3xT_{rot}) at R>20 au to describe the strength of the ^{12}CO v=2-1 lines.