HD 141569A: disk dissipation caught in action

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Located 116 pc away, HD 141569A is a 5 Myr old B9.5/A0Ve star, part of a wide triple system (stars B and C at ~1,000 au). HD 141569A is surrounded by a disk of dust and gas. The disk presents both properties of young and evolved objects: it contains a large amount of gas, thought to be still of primordial origin, while its dust content has been reprocessed and presents a complex structure. HD 141569A disk is thus of main interest to understand the evolution steps from proto-planetary to debris disks, especially as we only know two similar objects (HD 21997 and 49 Ceti). The planetary systems being shaped during this transition, a detail analysis of such objects can improve our understanding of the final stages of dissipation of proto-planetary disks and accretion of giant planets.

HD 141569A looks like a debris disk …

- SED: the *IRAS* telescope first detected an infrared excess, sign of surrounding material. The fractional luminosity $\mathbf{L_{disk}/L_* = 8x10^{-3}}$ [1] is typical of a debris disk (same magnitude as β Pictoris), the SED peaking at λ = 60 µm.
- *HST* images (λ ≈ 1 µm) [2,3,4,5,6] confirmed the presence of **evolved dust**, showing a multi-belt architecture and spirals, with a large depletion inside 125 au (Fig 2,3 and 6). The collision timescale is ~10^4 years [4] , implying the small dust grains have been reprocessed.
- The **low continuum mm flux density** (5.3 ± 1.1 mJy at λ = 1.35 mm, [7]) is another indication that the disk is evolved. Sub-millimetric observations imply a low dust mass: M_{dust} = 0.4 M_{Earth} (10^{-6} $M_\odot$) [8], while it is about 10^3 M_{Earth} (median value) in proto-planetary disks around T-Tauri stars [9].
- Several dynamical studies have tried to model the complex structure of the disk [10, 11, 12, 13], but none succeeded in reproducing the whole architecture. The main results emerging from these modelings to explain the disk shape are the need for one or more planets and the possible interaction with the companions stars.

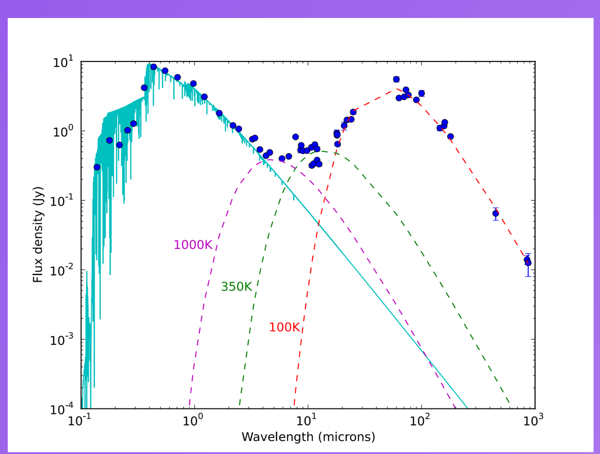


FIG 1: Spectral energy distribution of HD 141569A.

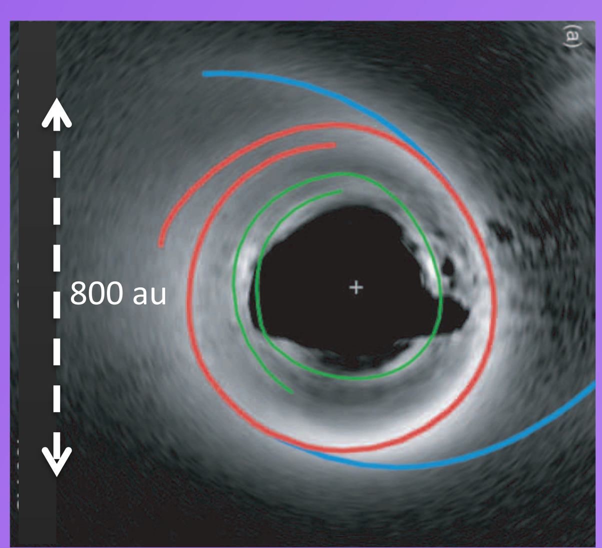


FIG 2: Deprojected HST image showing the spirals in the disk [3]. Orientation is the same as Fig 3.

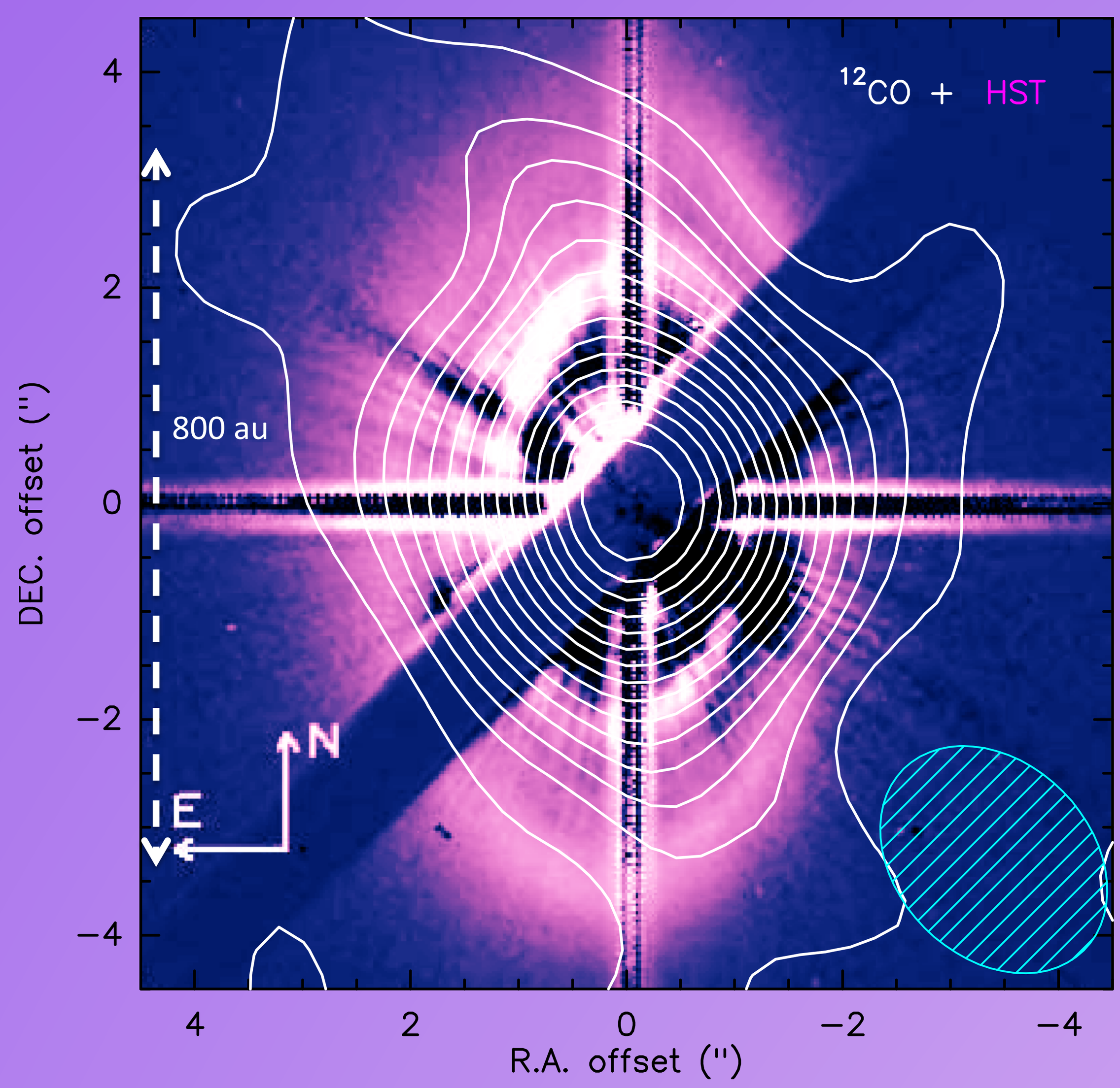


FIG 3: Contours of ^{12}CO(2-1) line emission (first at 5σ, with a 3σ step for the others) are super-imposed to the scattered light detected by the HST (coloured halo, [10]).

… but still contains CO gas

1 – Previous detections

- Cold ^{12}CO(2-1) was first detected with the IRAM 30-m telescope [14]. The *JCMT* also detected ^{12}CO(3-2). Models indicate the emission extends out to 250 au, with a likely multi-ring structure [15].
- Hot CO and atomic lines have also been detected [16,17]. Chemical models based on the observations lead to a total disk mass of 80-135 M_{Earth} ($2.4x10^{-4}$-$4x10^{-4}$ $M_\odot$) [18,17].

2 – PdBI observations

- We report the first resolved observations of ^{12}CO(J=2-1) and ^{13}CO(J=2-1) with the Plateau de Bure Interferometer (Fig 4). The detection of ^{13}CO proves there is still a large amount of gas in the disk (R_{out} ~300 au from ^{12}CO map).
- The recent observations also map the continuum at 230 GHz, which appears centrally peaked (4.0 ± 0.3 mJy) (Fig 5).

3 – Undergoing modeling

We will analyze the data with the code DISKFIT [19]. The simultaneous modeling of ^{12}CO and ^{13}CO will better constrain the excitation conditions and physical properties of the disk.

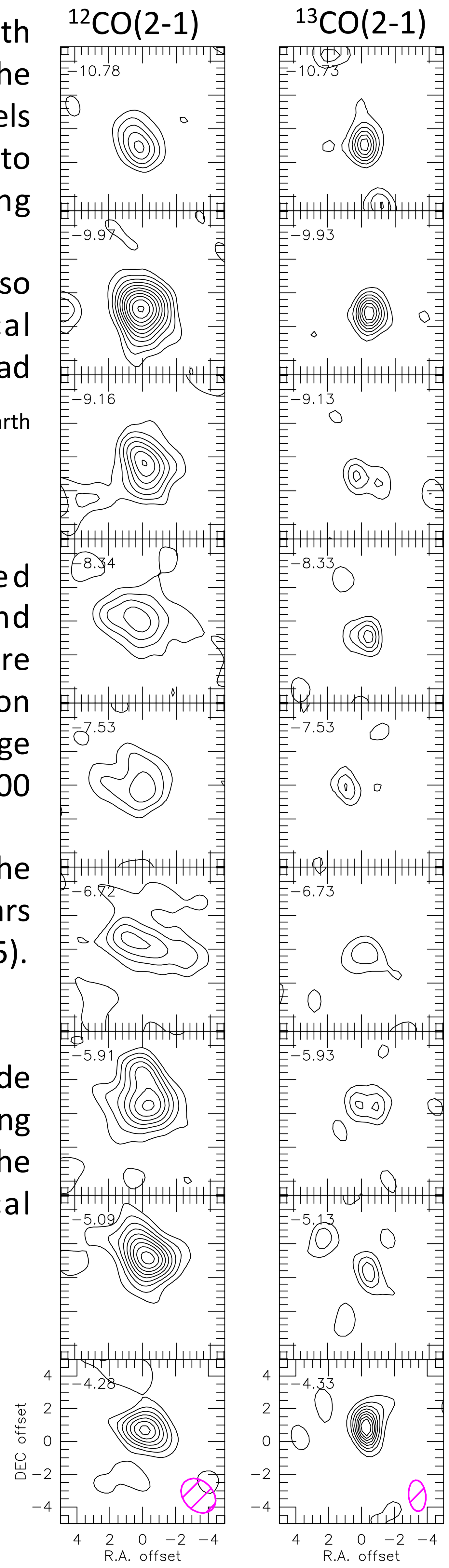


FIG 4: ^{12}CO(2-1) and ^{13}CO(2-1) channels.

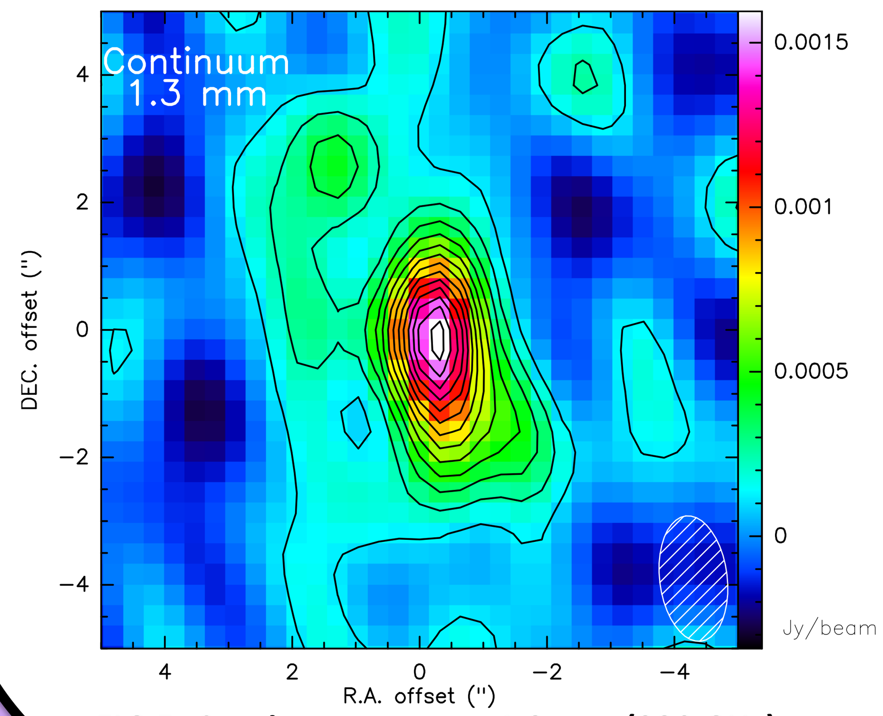
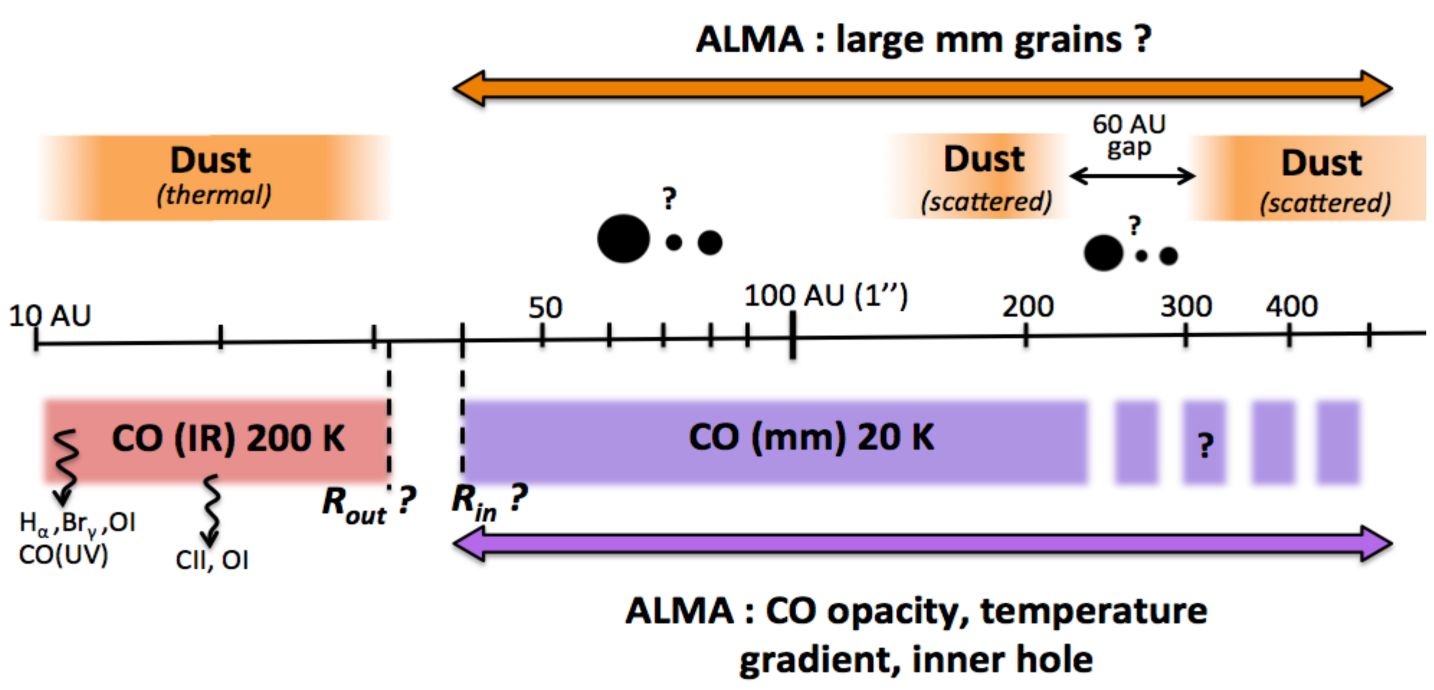


FIG 5: Continuum map at 1.3 mm (230 GHz).

FIG 6: General scheme of the HD 141569A disk structure.



Is HD 141569A part of a new class of objects: hybrid disks ?

- HD 141569A cannot be classified as pure debris nor proto-planetary disk, having properties of the two classes.
- Our observations reveal a different architecture for the gas and for the dust; it could be a lack of resolution effect for the ^{12}CO map, or a real difference. In the latter case, it may be caused by a different origin for the two components (primordial gas and secondary-made dust).
- The large quantity of gas is still to be explained. Its presence is difficult to reconcile with a scenario invoking planetesimals/comets destruction. The CO photodissociation timescale (~10^3 yr) would require a CO evaporation rate of $4x10^{-7}M_{Earth}.yr^{-1}$ (i.e. evaporation of ~10^4 typical comets per year) [18]. The CO is thus likely a remnant of the primordial gas, while the dust has been reprocessed, similarly to the hybrid disk HD 21997 [20,21], and the more debated 49 Ceti disk [22].
- The detailed study of this object should improve our knowledge of the dissipation mechanisms of the gas, and its possible consequences on the shaping of the planetary system.

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