From Star to Planet Formation

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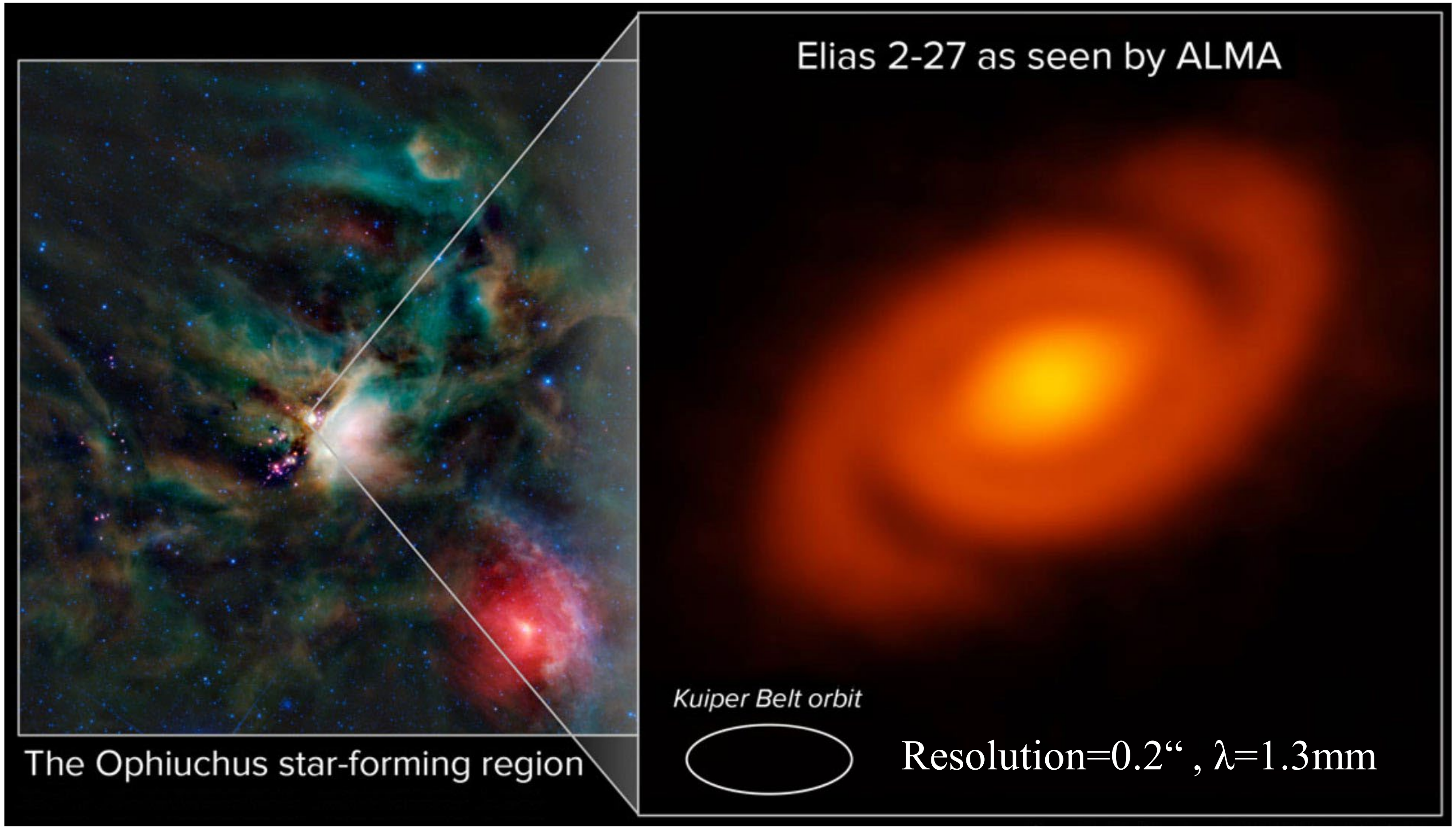


Perez et al. (incl. Henning) (2016), Paneque-Carreño et al. (incl. Henning) (2021)

The Challenges

- How is angular momentum and mass transported to the disk?
(streamers, inclined inner disks, evolution of organics)

- Steady versus continuous accretion?
(Magnetic breaking, clump accretion, early FU Ori bursts)

- How early is early? – Planet Formation in embedded disks?
(embedded disk structure, grain dynamics and growth)

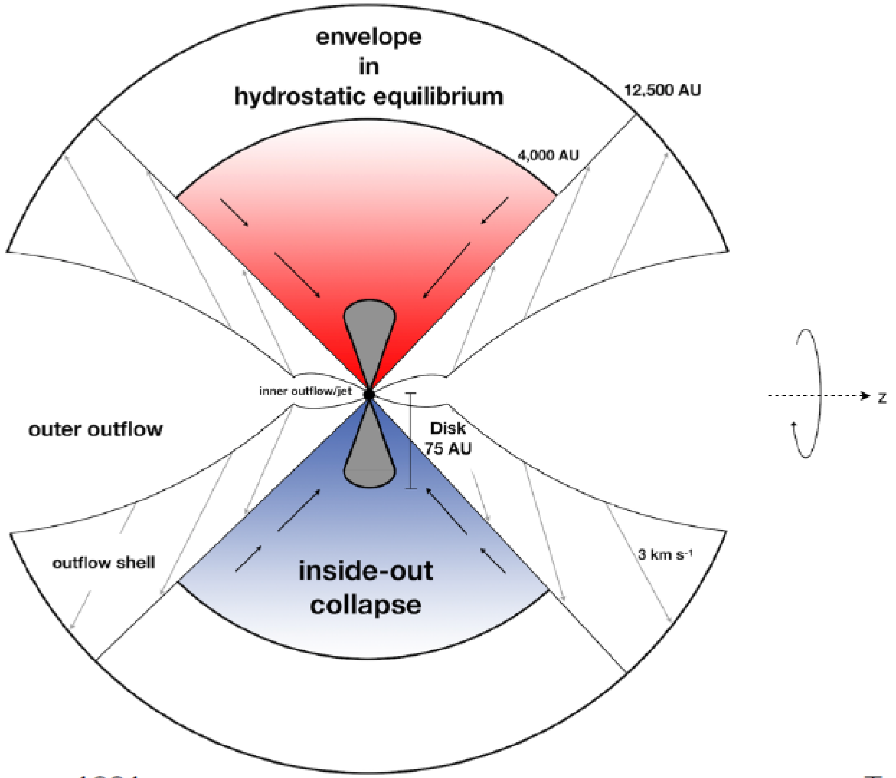
Molecular Cloud Core Collapse – The „Present“ View

Differences lies in the **outer envelope**:

Schematic diagram of L1527.

UCM

- *Neglect* gas pressure support.
- Infall velocity is *non-zero* after 4,000 AU.



TSC

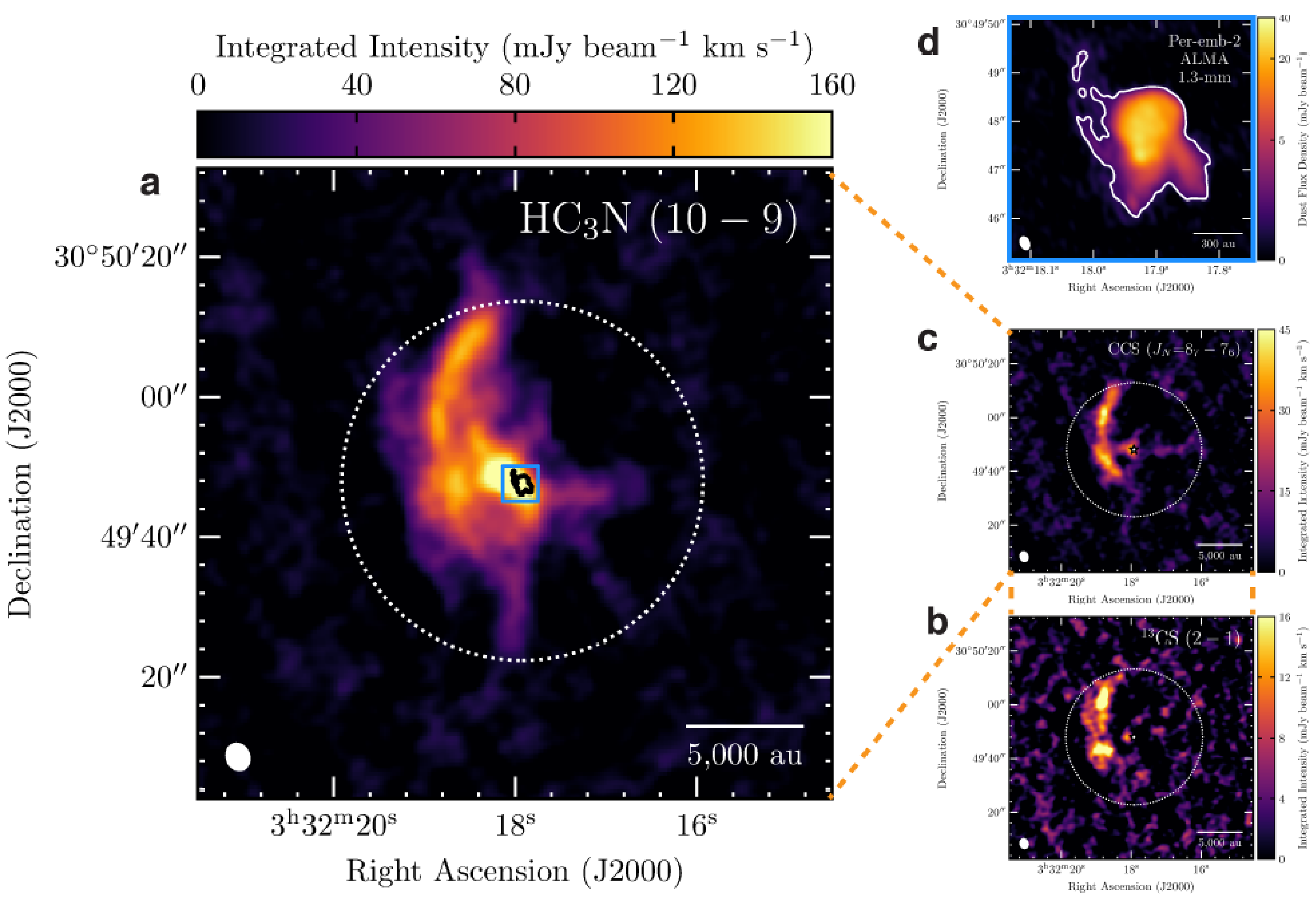
- *Considers* gas pressure support.
- Infall velocity is *zero* after 4,000 AU.

Ulrich 1976; Cassen & Moosman 1981

Terebey, Shu, & Cassen 1984

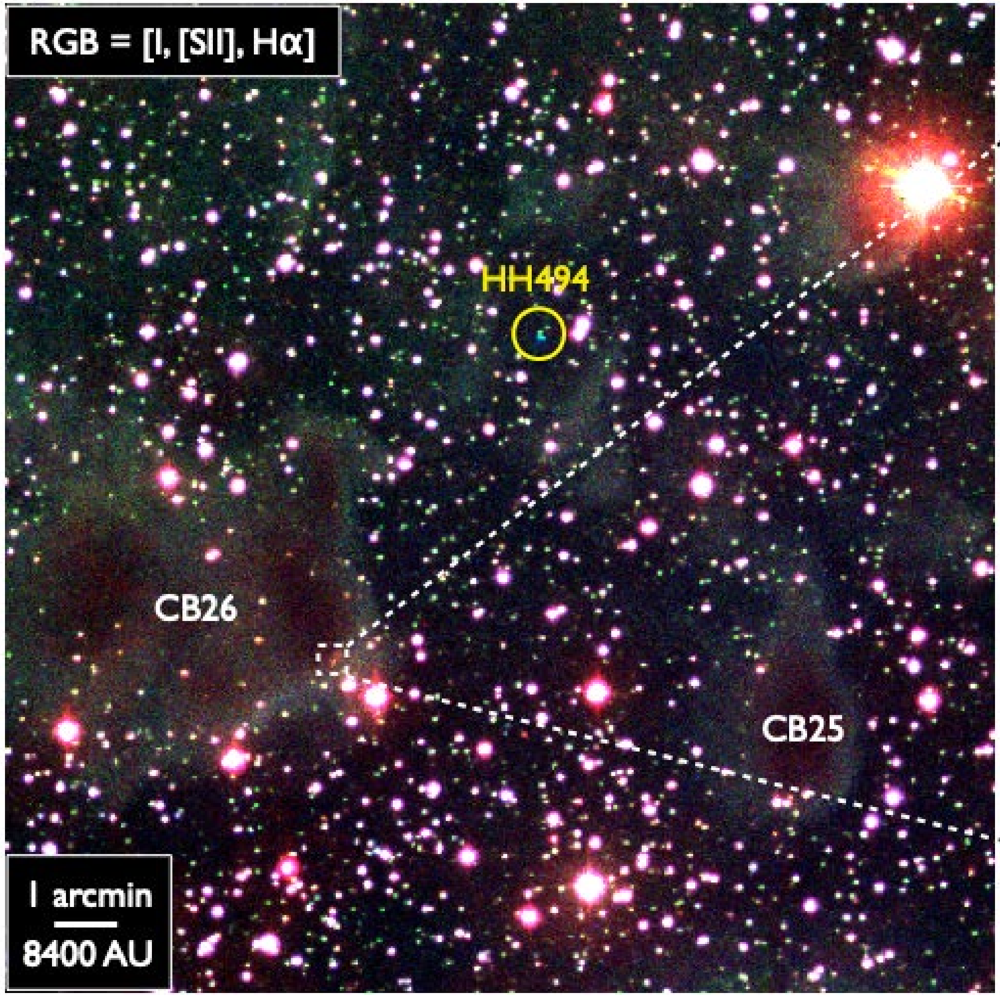
(After Flores-Rivera et al. 2021)

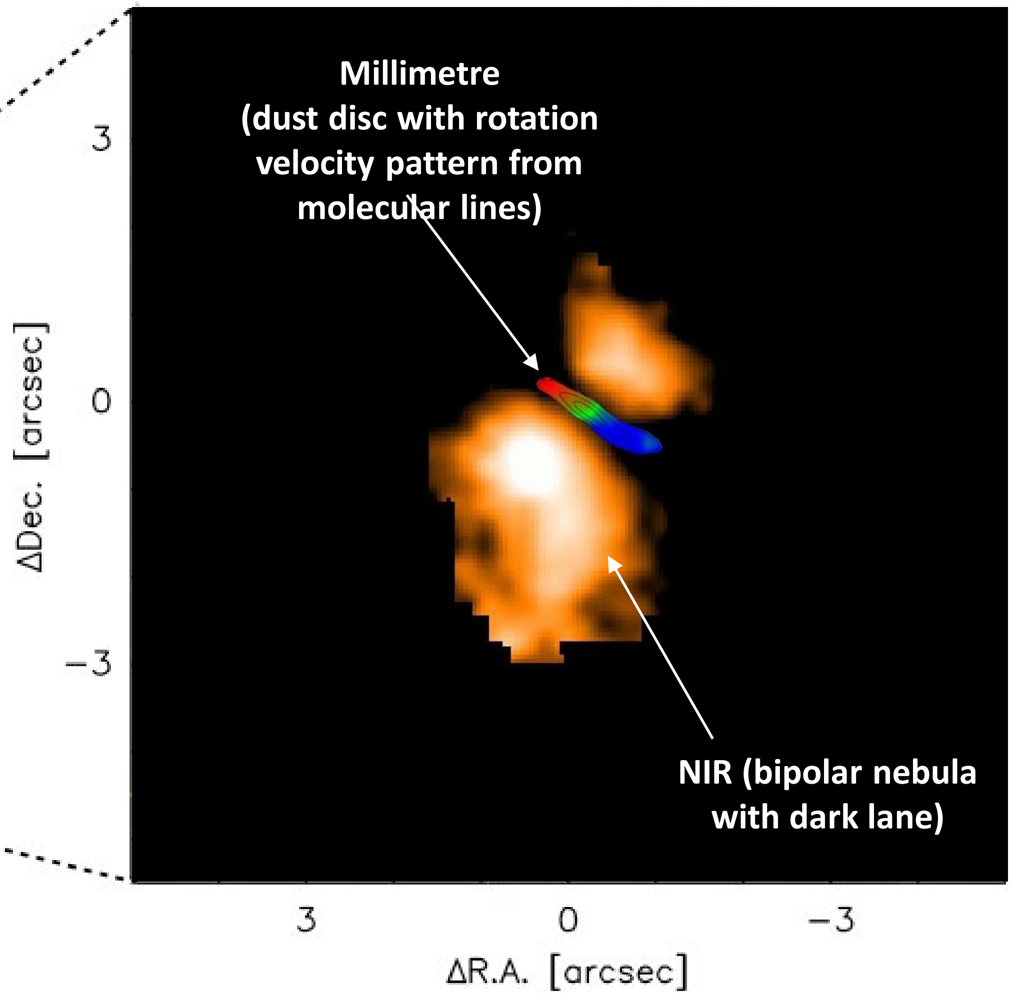
Accretion through Filaments



Per.emb 2 in Perseus with ALMA: Pineda et al. (2020)

CB26-mm: A Protoplanetary Disc Embedded in a Bok Globule





Globules in the Taurus-Auriga region at 140±20 pc; DEC +52° (out of reach for ALMA)

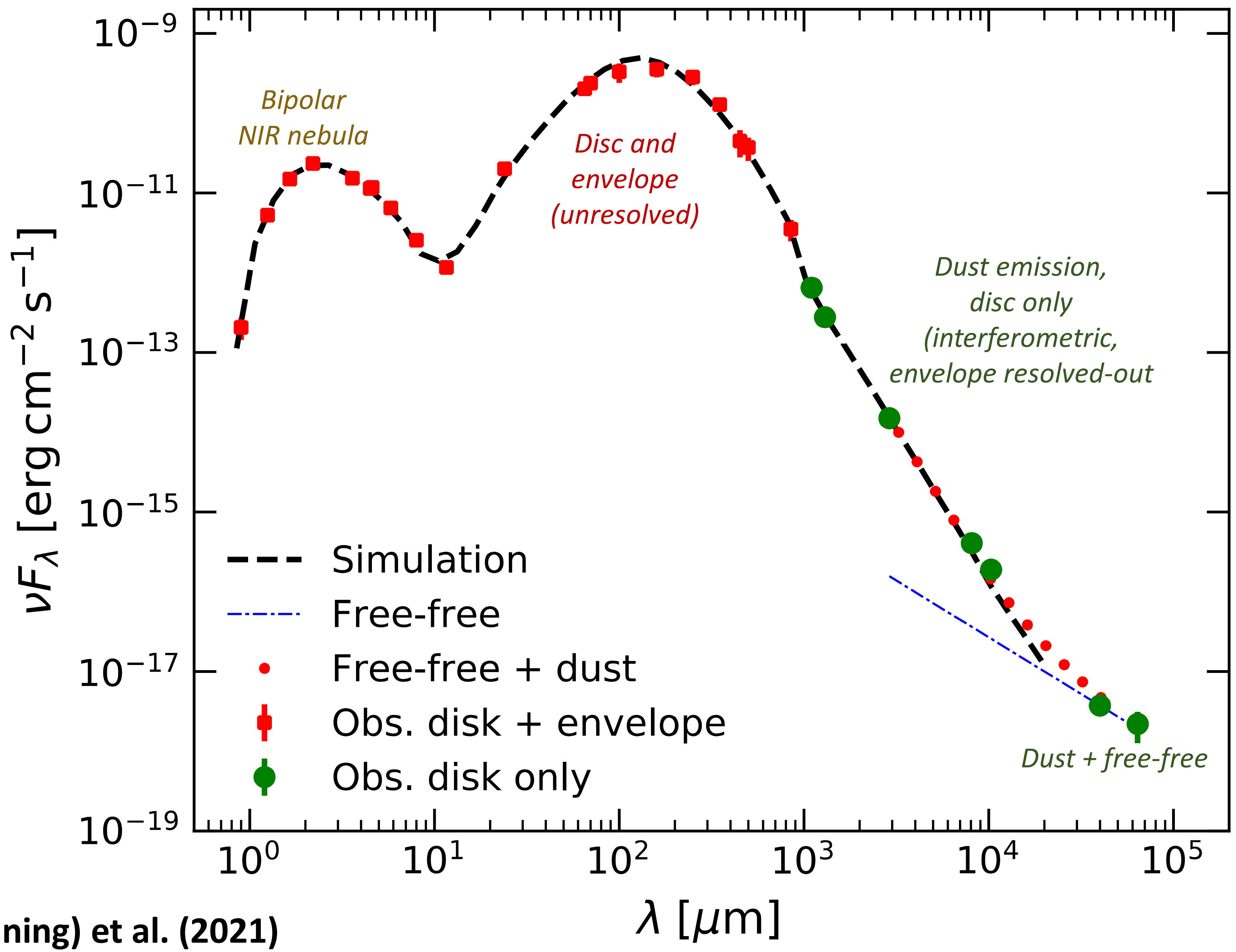
Star mass: $0.55 \pm 0.1\ M_\odot$ *(from disc rotation)*

Disc mass: $\approx 0.1\ M_\odot$

Disc radius: 200 au

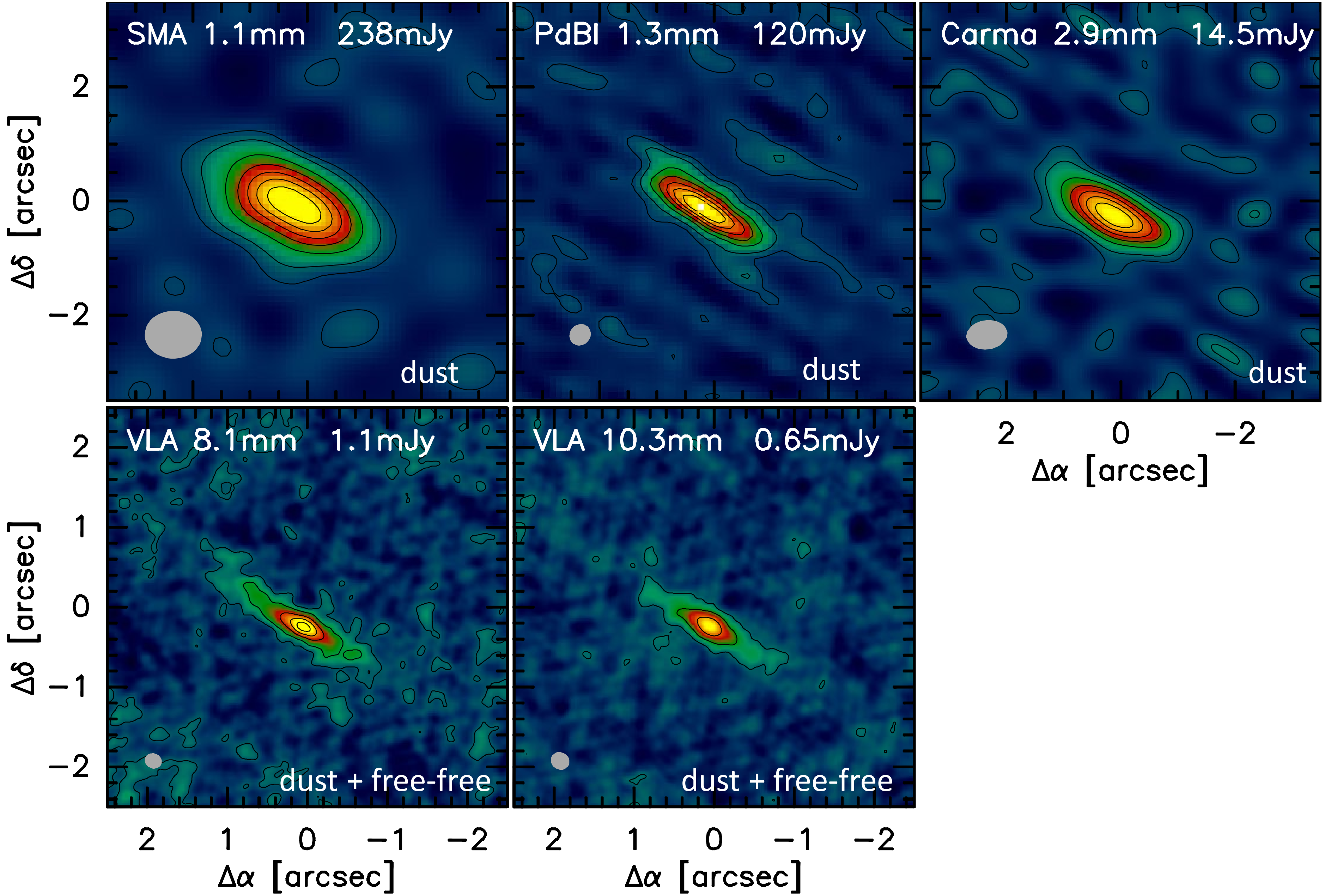
Age: $1^{+1}_{-0.5}$ Myr *(Launhardt ea. 2014)*

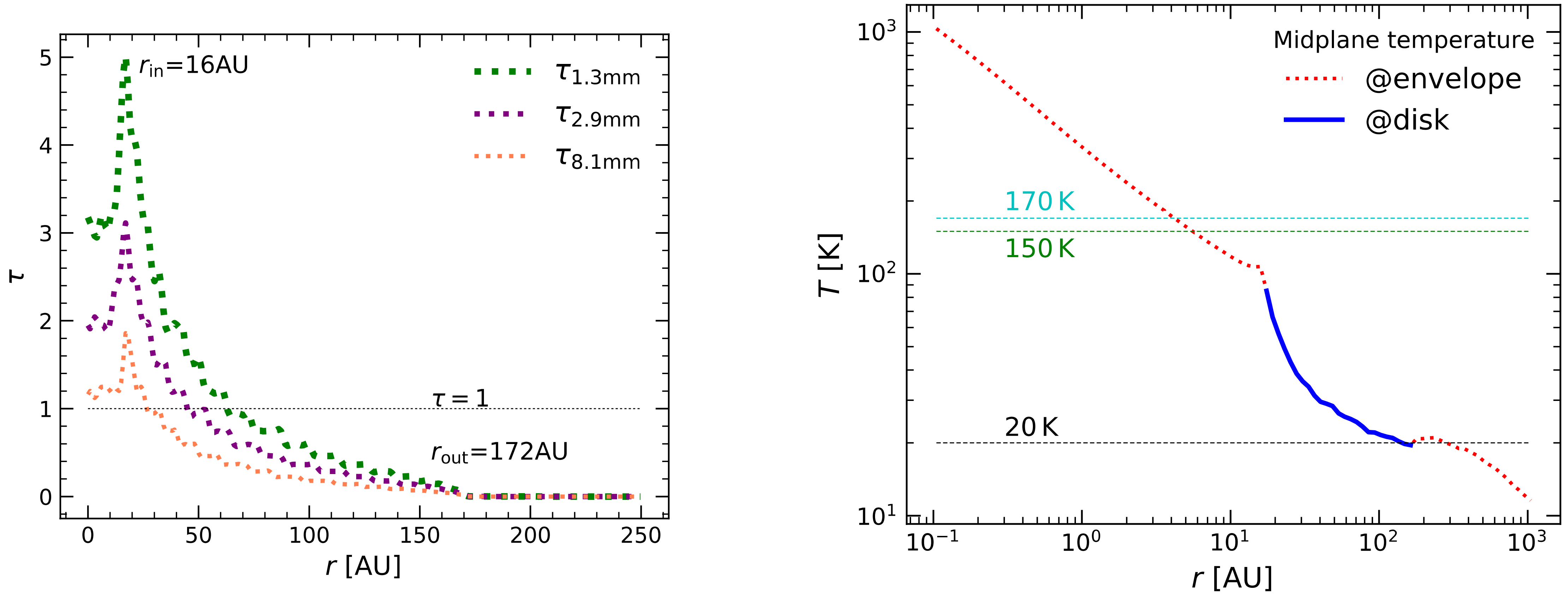
Spectral Energy Distribution



Zhang et al. (incl. Henning) et al. (2021)

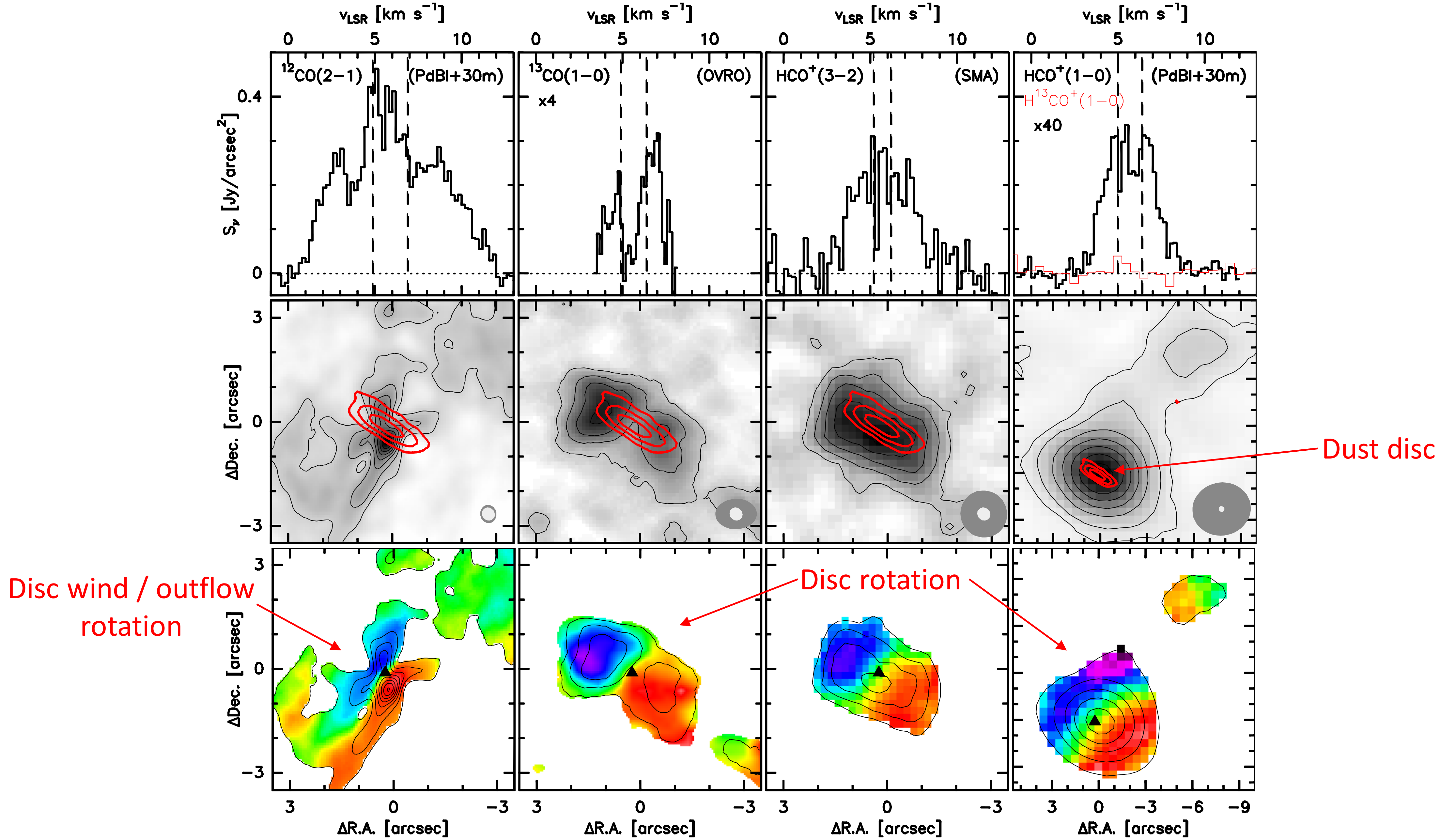
Millimetre Continuum Data





r_{in}=16AU
$\tau_{1.3mm}$
$\tau_{2.9mm}$
$\tau_{8.1mm}$
$\tau = 1$
r_{out}=172AU
τ
0
1
2
3
4
5
0
50
100
150
200
250
r [AU]
Midplane temperature
@envelope
@disk
170 K
150 K
20 K
T [K]
10^3
10^2
10^1
10^{-1}
10^0
10^1
10^2
10^3
r [AU]

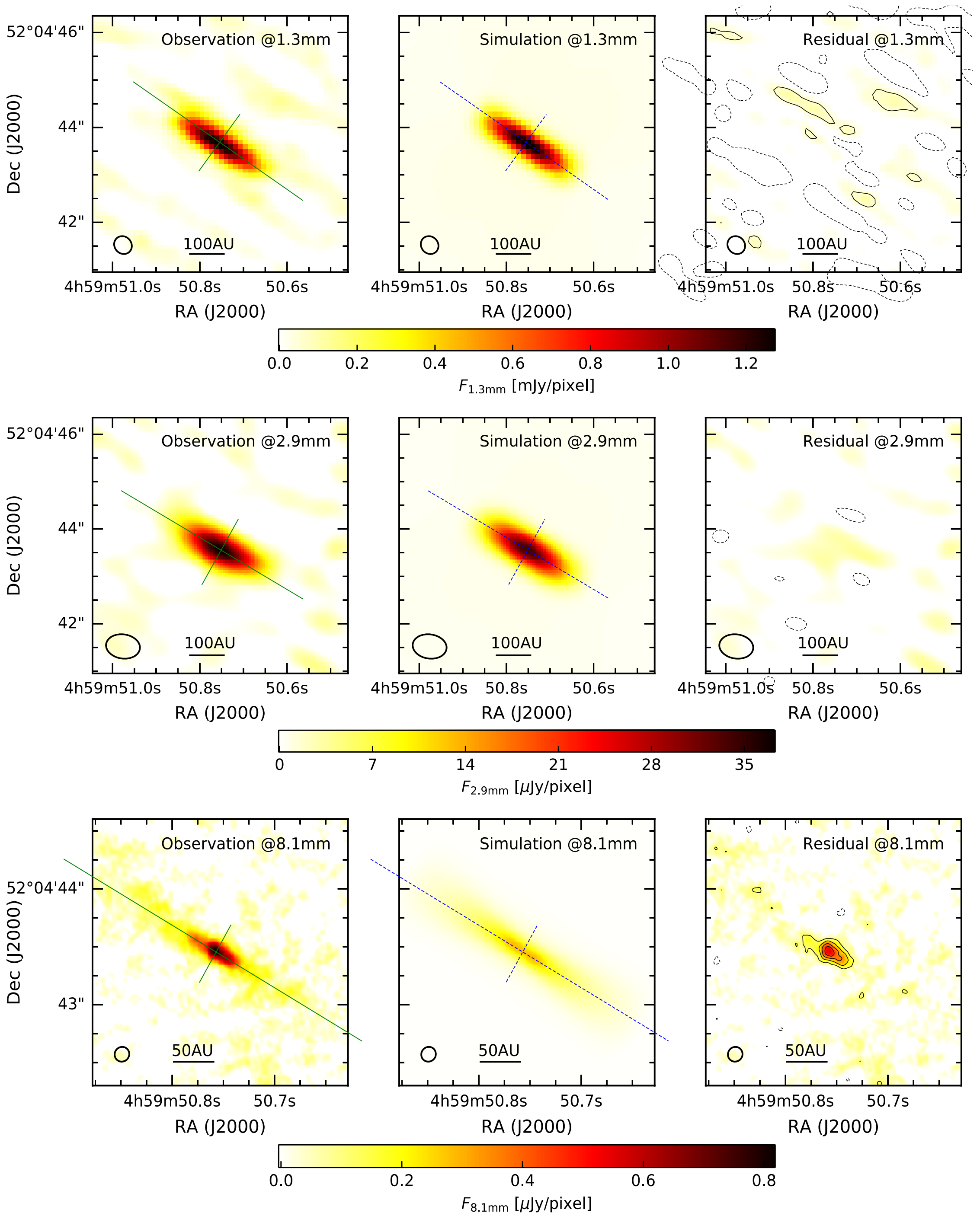
Molecular line data



Disc modelling approach

- Combination of SED with high-resolution continuum maps (RADMC-3D)
- Optical data: Carbon and silicates (DL model)
- Shakura-Sunyaev (1973) accretion disk density profile
- Sophisticated eploration of parameter space
- Disks mass is: $7.6 \times 10^{-2}\ M_{sun}$

Dust Grains have grown to 10 cm-sized pebbles and larger


Observation @1.3mm
Simulation @1.3mm
Residual @1.3mm
52°04'46"
44"
42"
Dec (J2000)
100AU
4h59m51.0s
50.8s
50.6s
RA (J2000)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
F1.3mm [mJy/pixel]
Observation @2.9mm
Simulation @2.9mm
Residual @2.9mm
0
7
14
21
28
35
F2.9mm [μJy/pixel]
Observation @8.1mm
Simulation @8.1mm
Residual @8.1mm
52°04'44"
43"
50AU
4h59m50.8s
50.7s
F8.1mm [μJy/pixel]

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