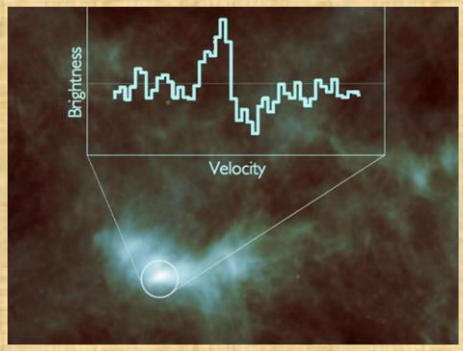
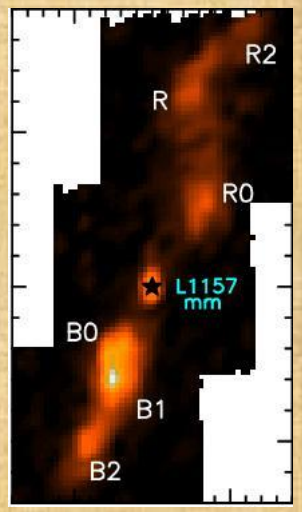
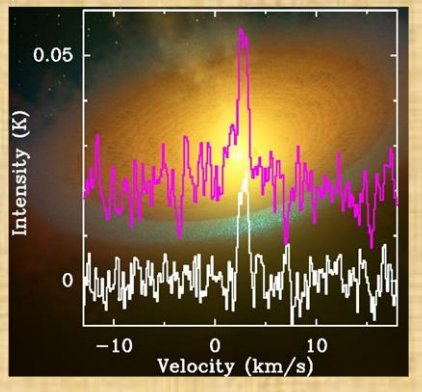


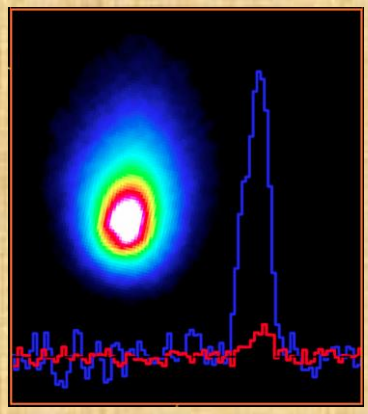
Caselli+ 2012



Nisini+ 2010



Hogerheijde+ 2011

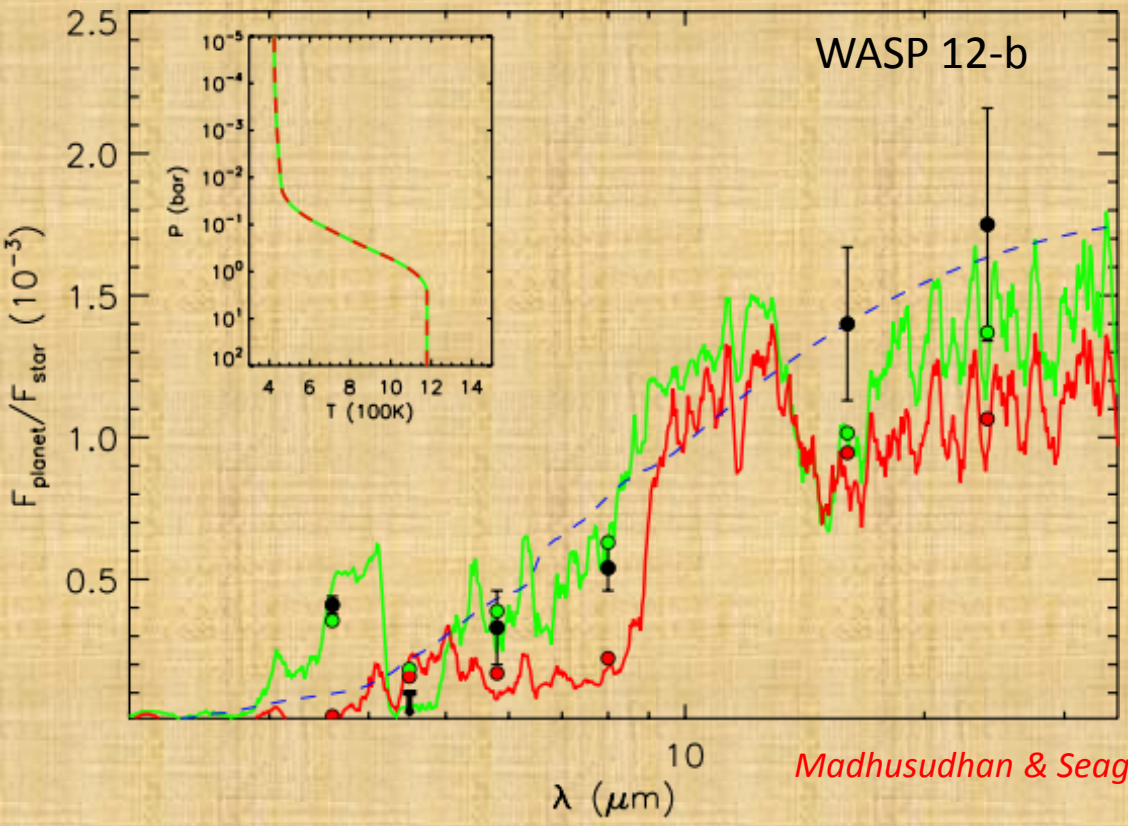


Hartogh+ 2011

Chemical composition of Herbig AeBe disks

D. Fedele

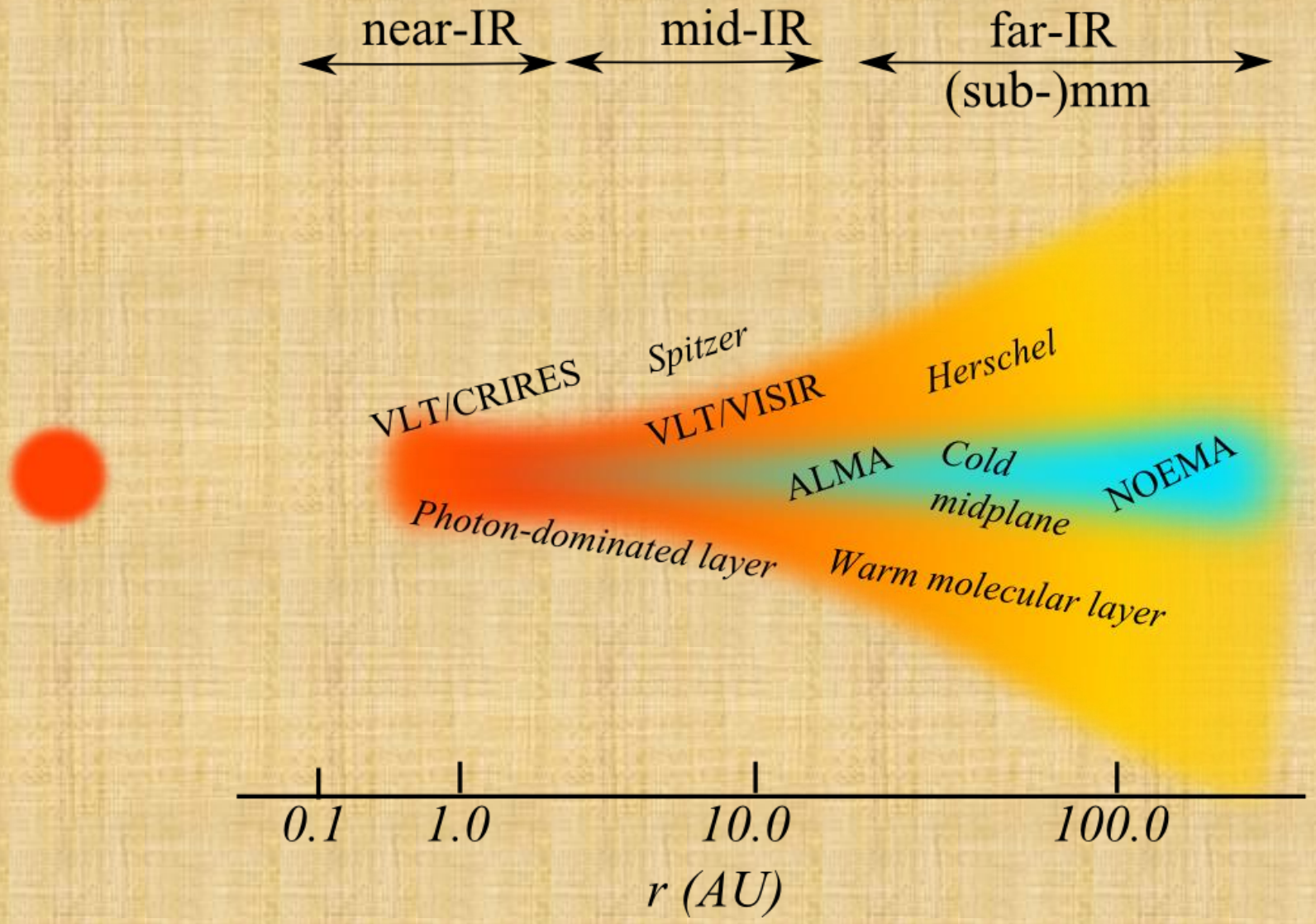
$(C/O)_{planet} \sim 1 > (C/O)_{star}$



Madhusudhan & Seager 2011

- M_* – Disk chemistry
- Implications for planetary atmosphere

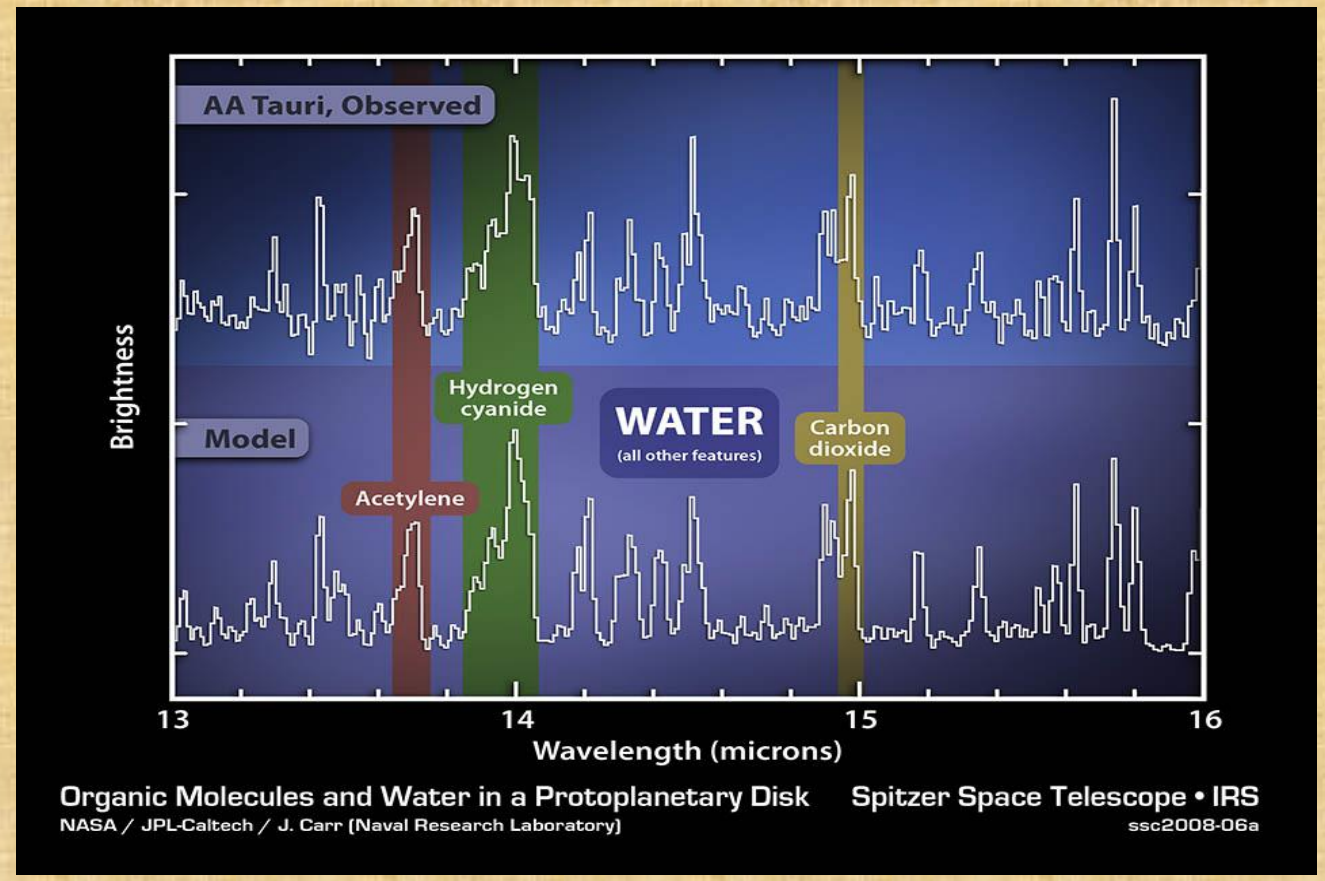
- Chemical composition of disks
- Radial distribution of different species


near-IR
mid-IR
far-IR
(sub-)mm
VLT/CRIRES
Spitzer
VLT/VISIR
Herschel
ALMA
Cold
midplane
NOEMA
Photon-dominated layer
Warm molecular layer
0.1
1.0
10.0
100.0
r (AU)

Outline

- Gas in the inner disk
- Gas in the outer disk
- Gas temperature gradient
- Take home messages and future perspective

Gas in the inner disk



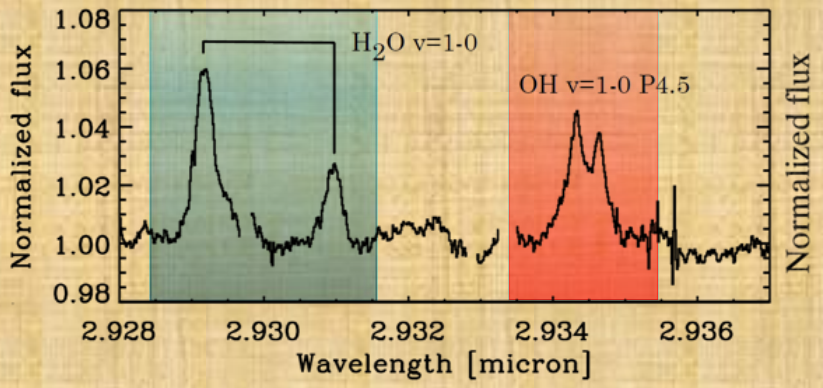
e.g.
Carr & Najita 2004
Thi & Bik 2005
Carr & Najita 2008
Salyk+ 2008
Pontoppidan+ 2010

e.g.
Glassgold+ 2009
Woitke+ 2009
Meijerink+ 2009
Bethell & Bergin 2010
Najita+ 2011
Adamkovics+ 2014

Poster by S. Antonellini

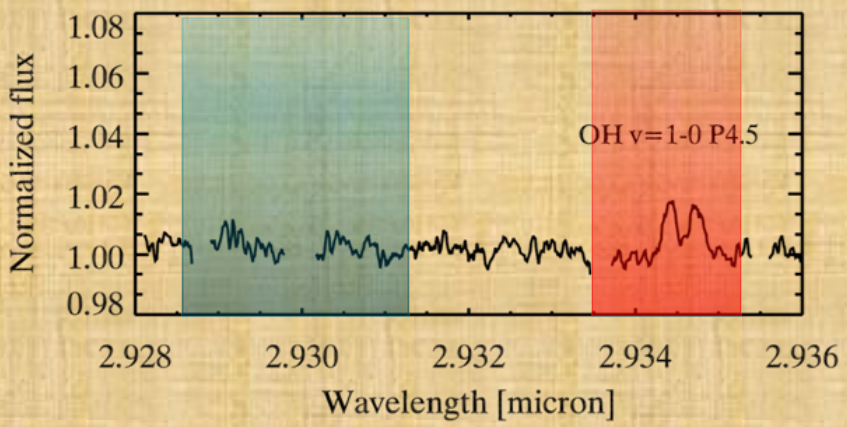
Abundant (~ 10^{17} cm^{-2}) H_2O in disks around TTs

AS 205 (K5)



Salyk+ 2008
Pontoppidan+ 2010

HD 250550 (B9)



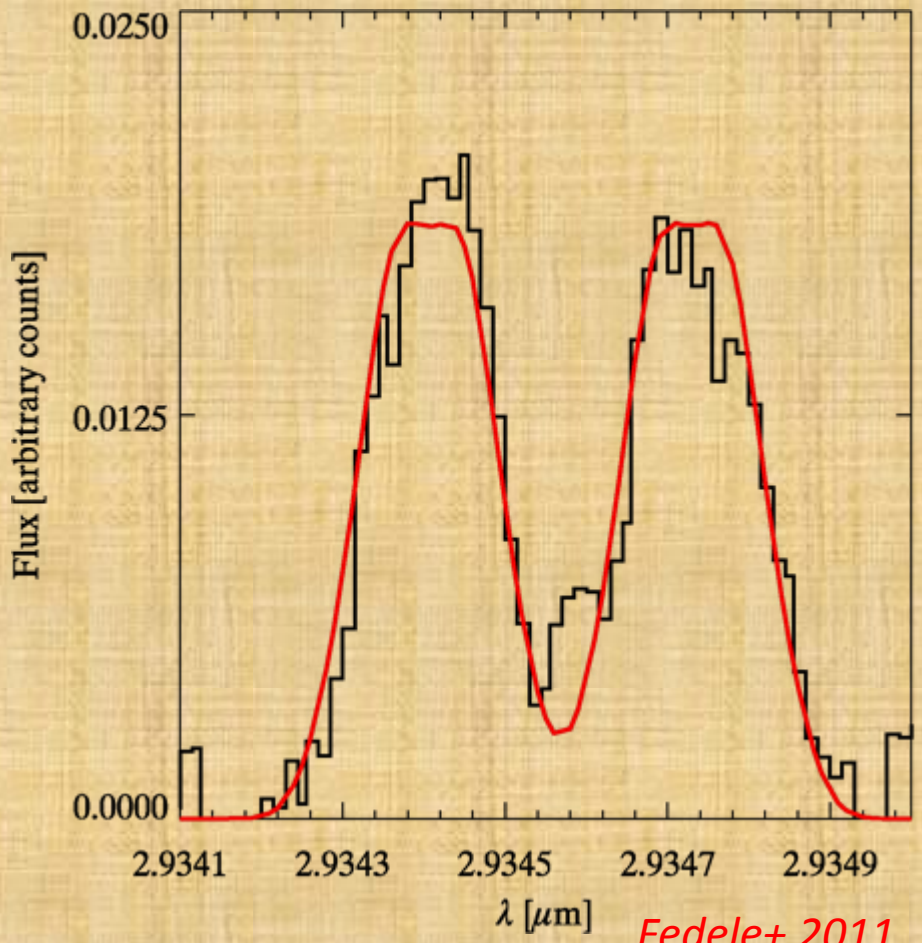
Fedele+ 2011
Liskowsky+ 2012
Mandell+ 2008

HAeBe disks, no ``hot'' H_2O

HD 250550 (B9)

R_{in}(OH) = 0.5 AU

i = 10°

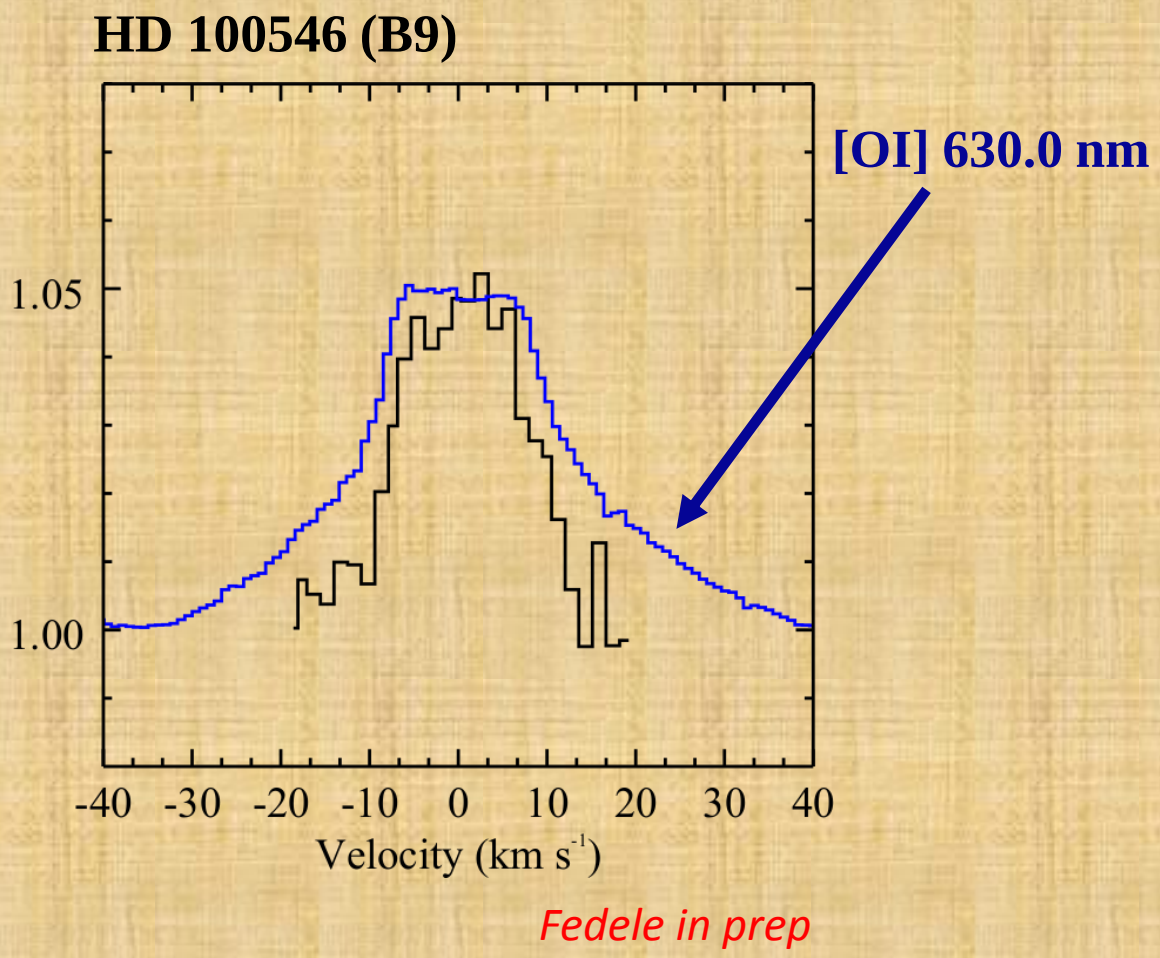


Fedele+ 2011

OH in HD 100546

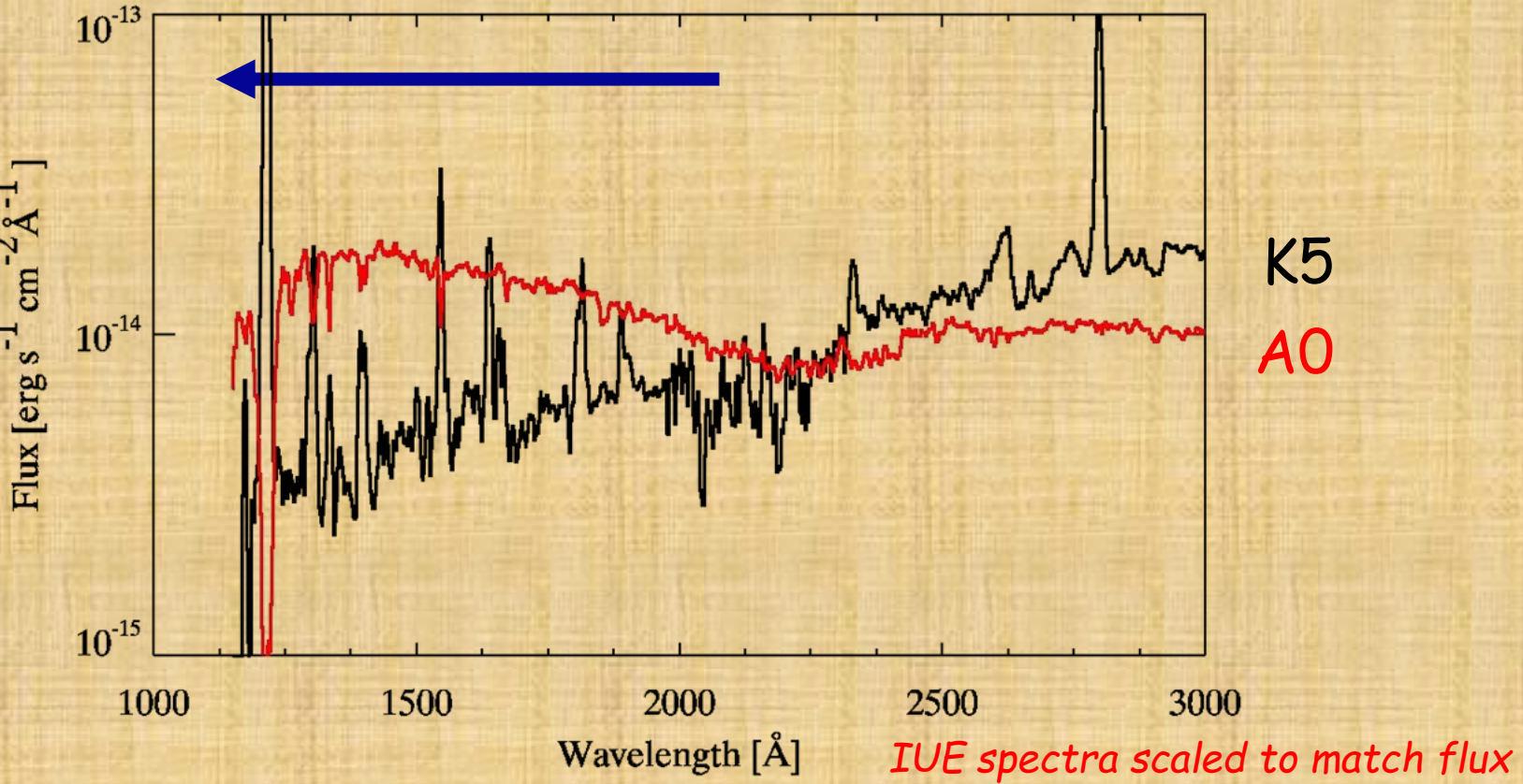
No evidence of asymmetry

Lack of high-velocity OH within 13 au (similar to CO)



Fedele in prep

H_2O Photodissociation



HAeBe disks, no "hot" H_2O

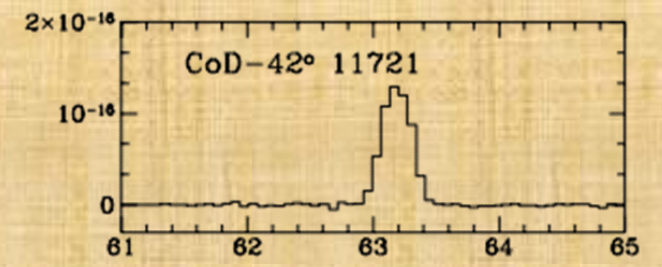
Gas in the outer disk

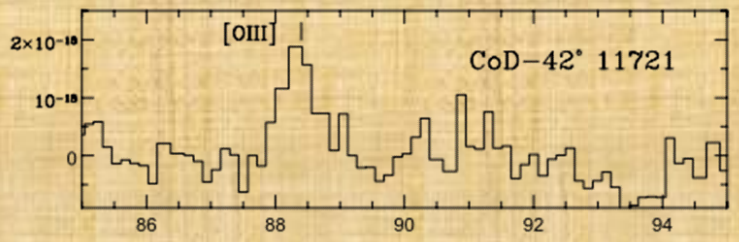
N. Evans

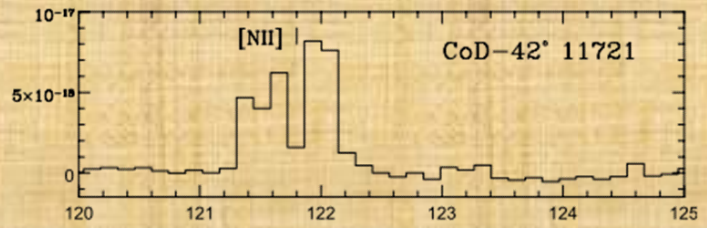
Bouwman, J., Herczeg, G., Green, J.,

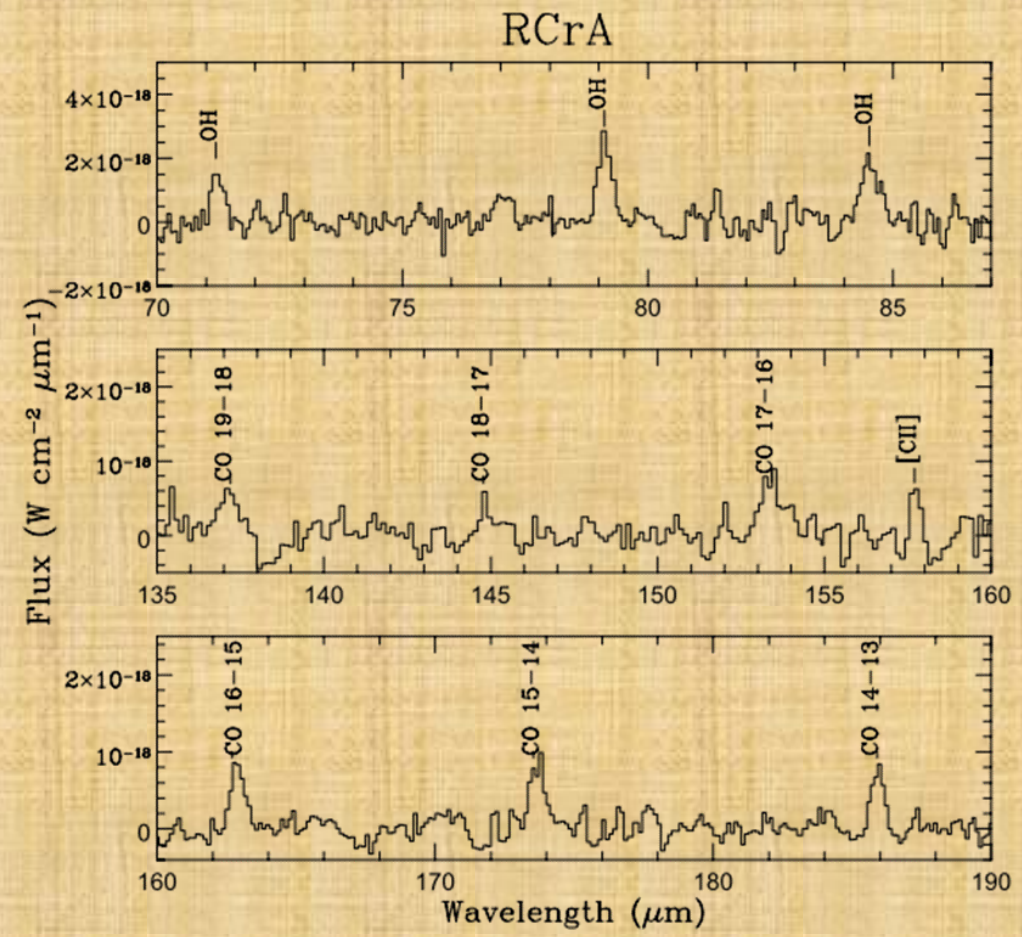
Bruderer, S., Meeus, G., Henning, Th.,

van Dishoeck, E.F., Carr, J.



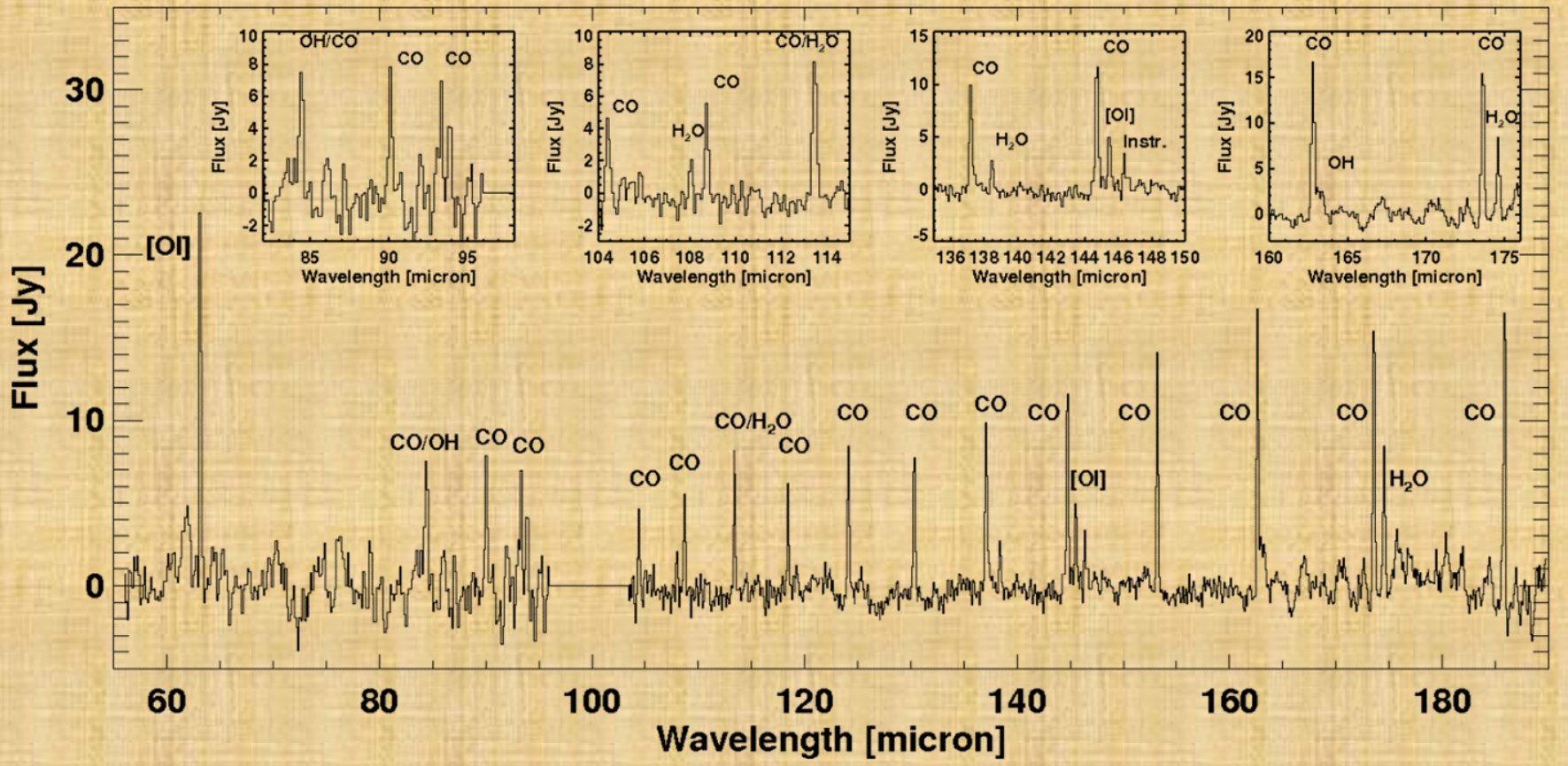






Giannini+ 1999, Lorenzetti+ 2000, van den Ancker+ 2000

ISO detections: [OI], [CII], [NII], OH, CO



van Kempen+ 2010, Sturm+ 2010
Thi+ 2011, Meeus+ 2012, Fedele+2012, 2013a

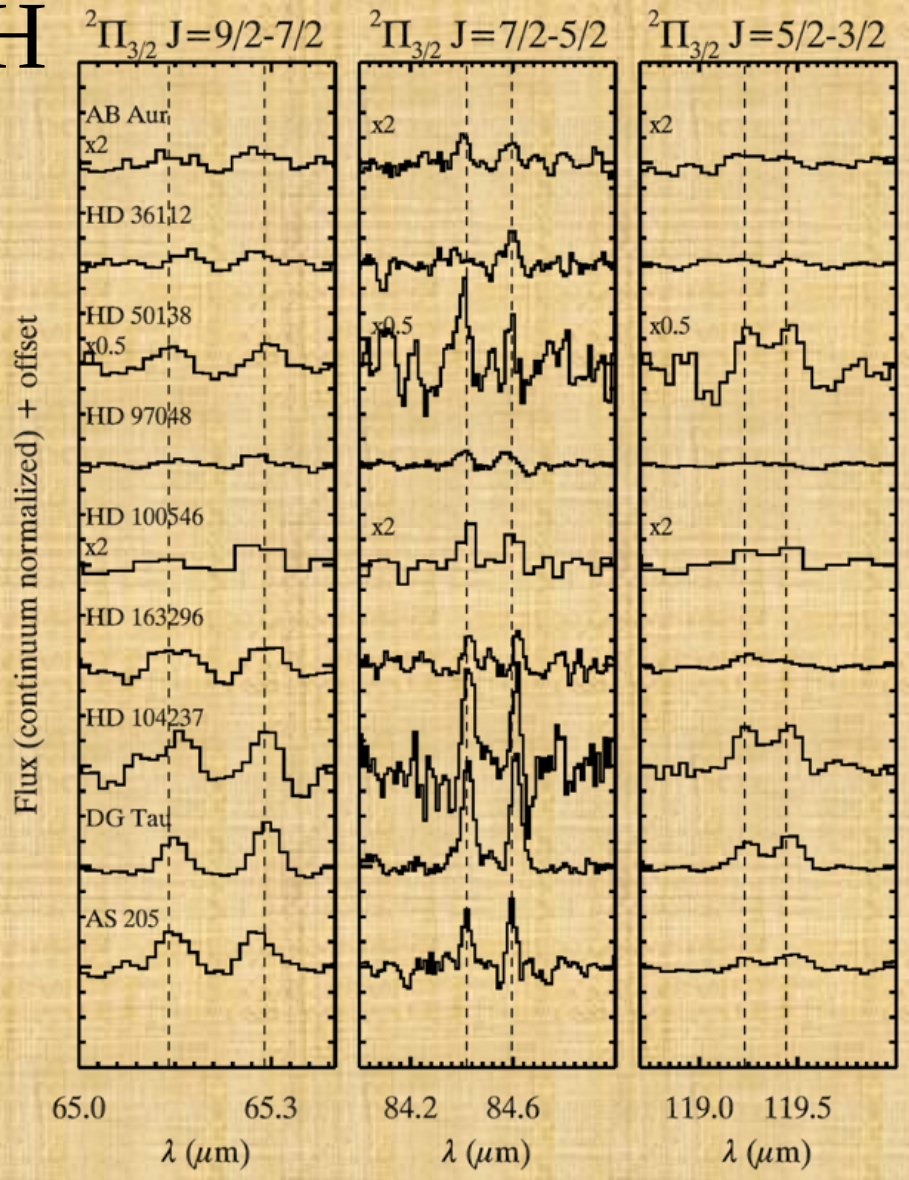
[OI], [CII], OH, H_2O, CO, CH+

Molecular emission: OH

After [OI], OH is the most common feature

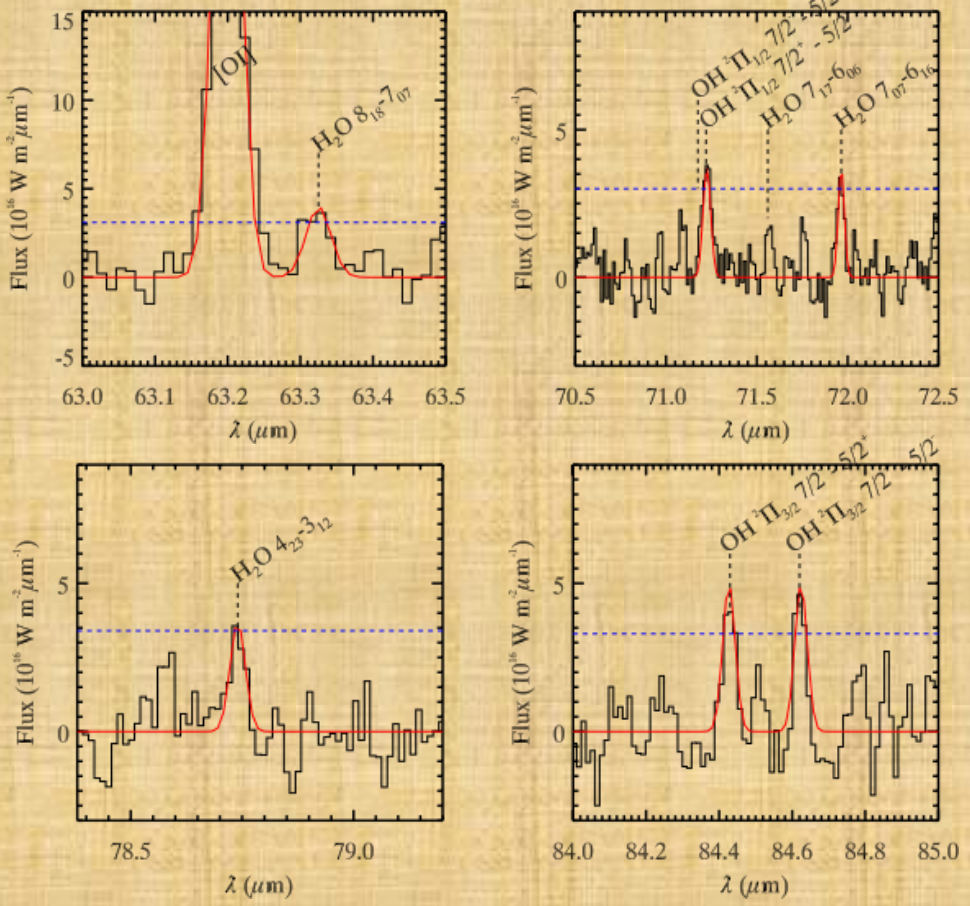
Multiple OH doublets detected

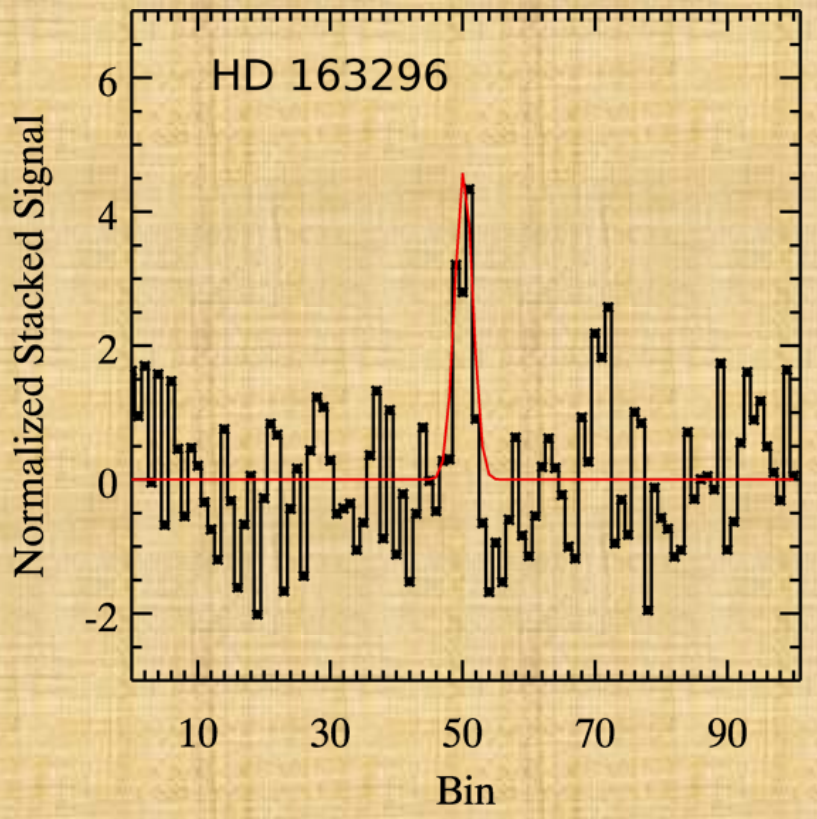
$E_u \sim 100 - 900$ K



Fedele+ 2013a

Warm H_2O in HD 163296

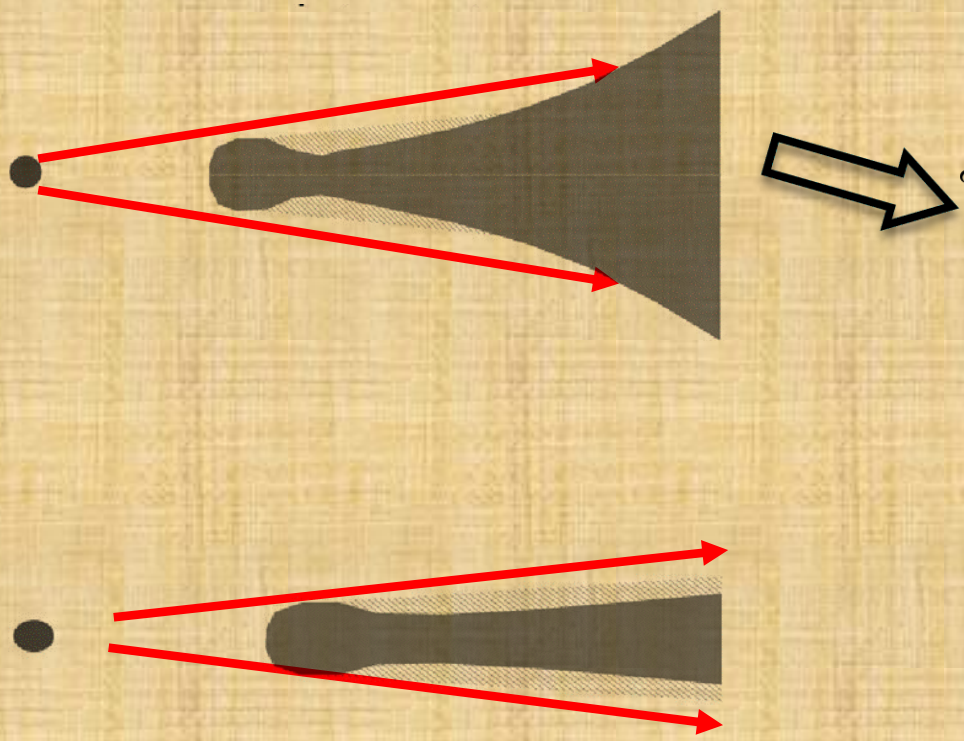


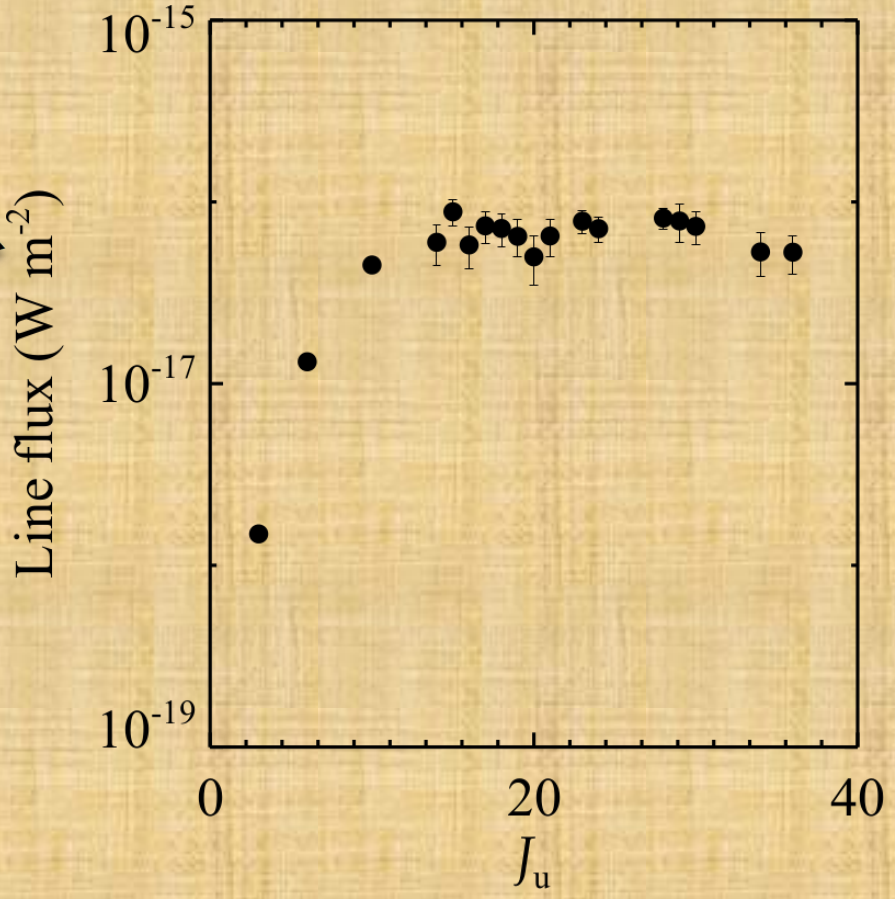


Fedele+ 2012, Meeus+ 2012

(Tentative) Detection in HD 104237, HD 142527

Molecular emission: CO

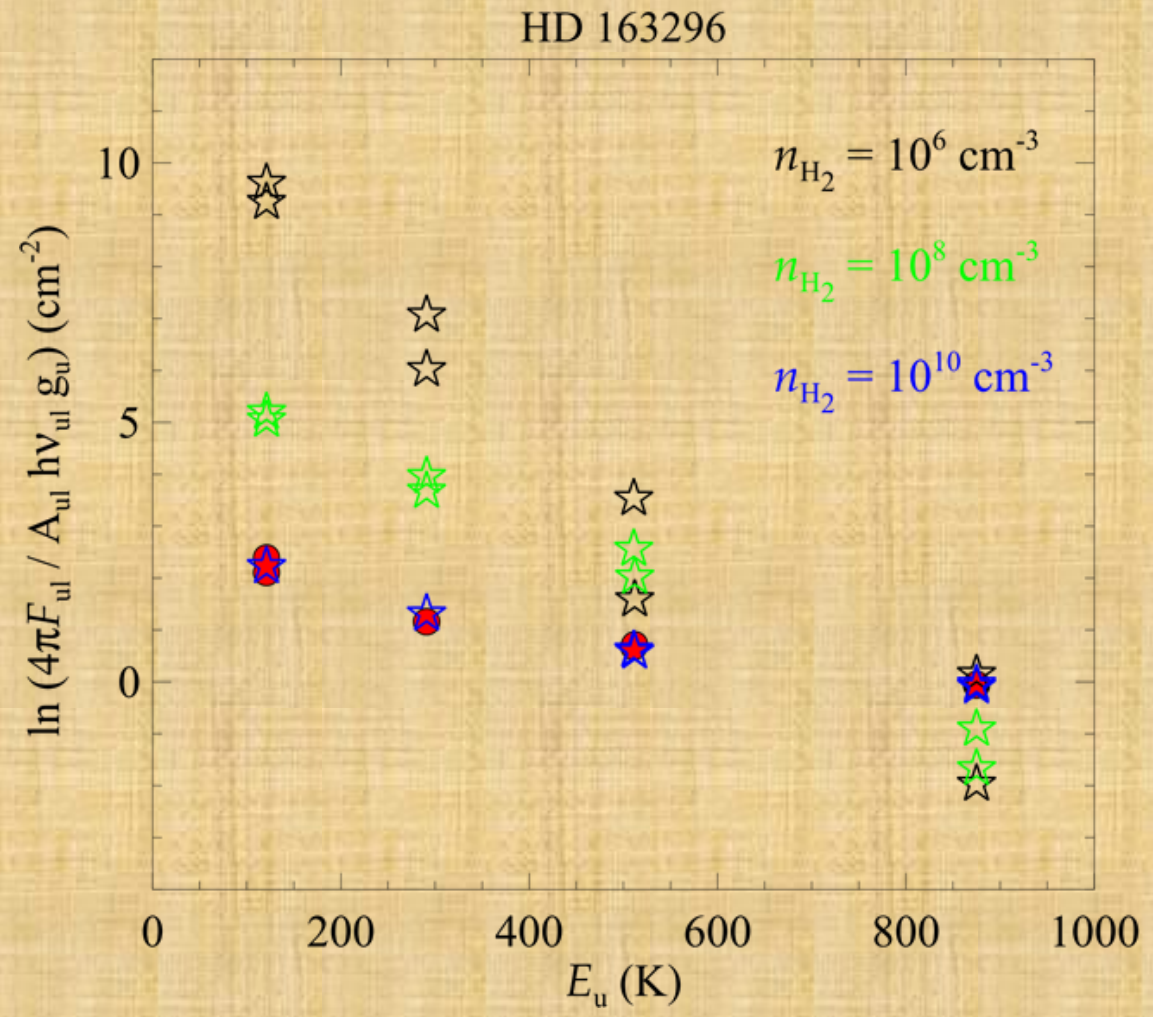




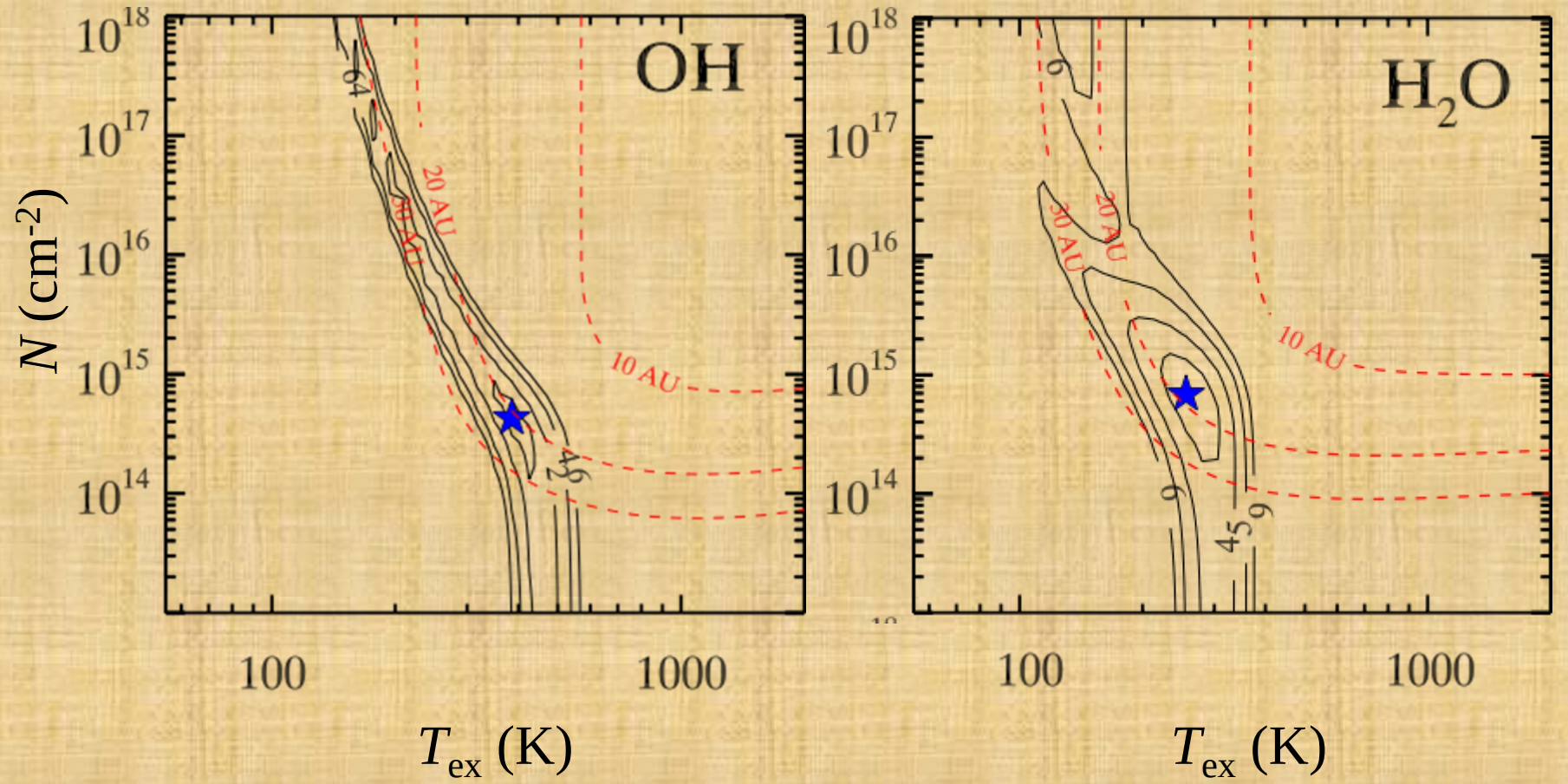
CO only in Group I disks

Meeus+ 2013

Molecular emission: T_{ex}, N

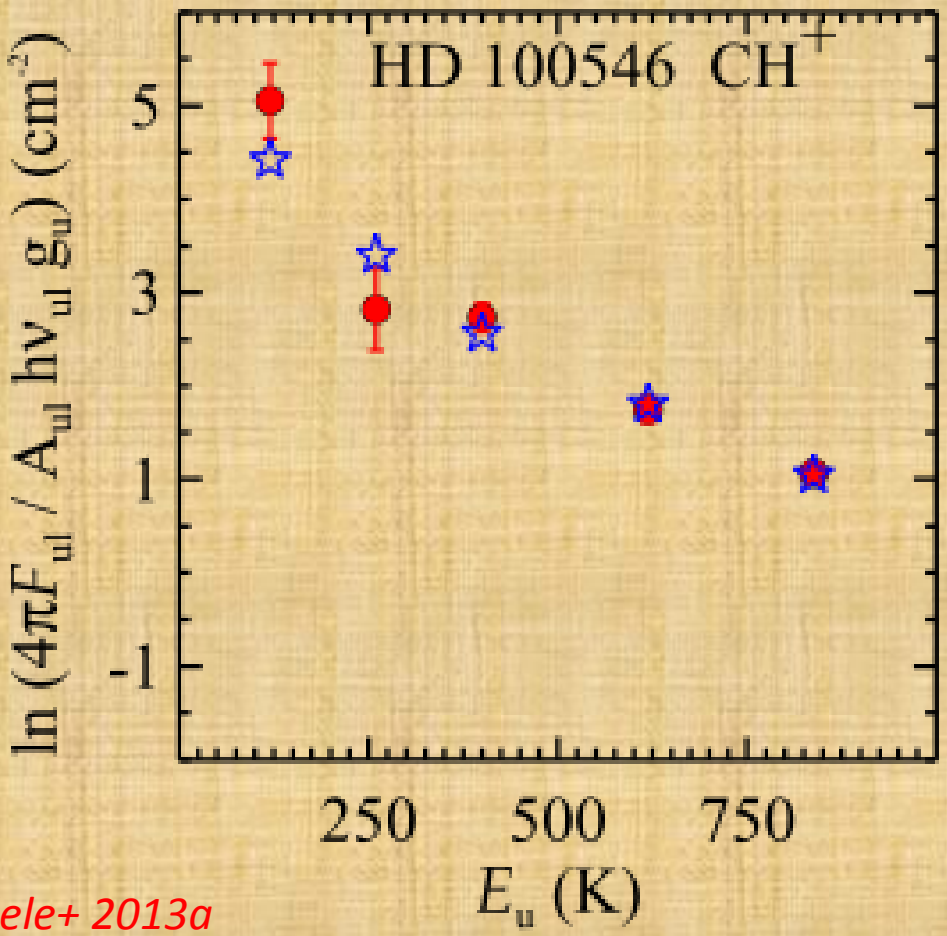


Fedele+ 2013a



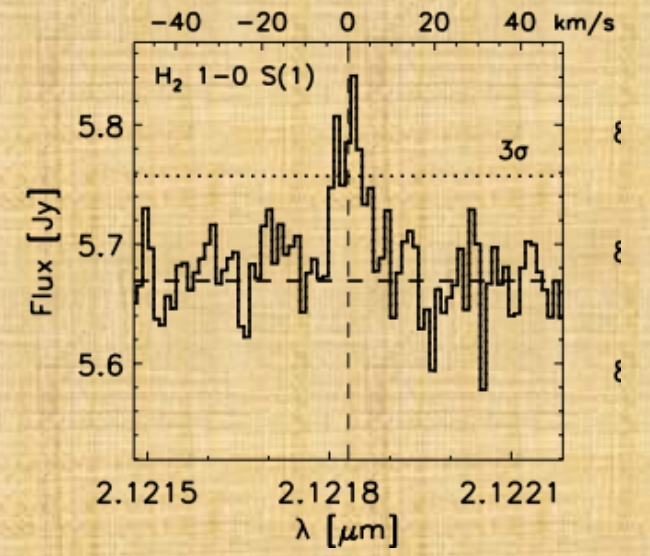
Fedele+ 2013a

$R(CH^+) \sim 50 - 100$ au



Fedele+ 2013a
Thi+ 2011

$R(H_2) \sim 50$ au



Carmona+ 2011

H2* + [CII] → CH^+ + H

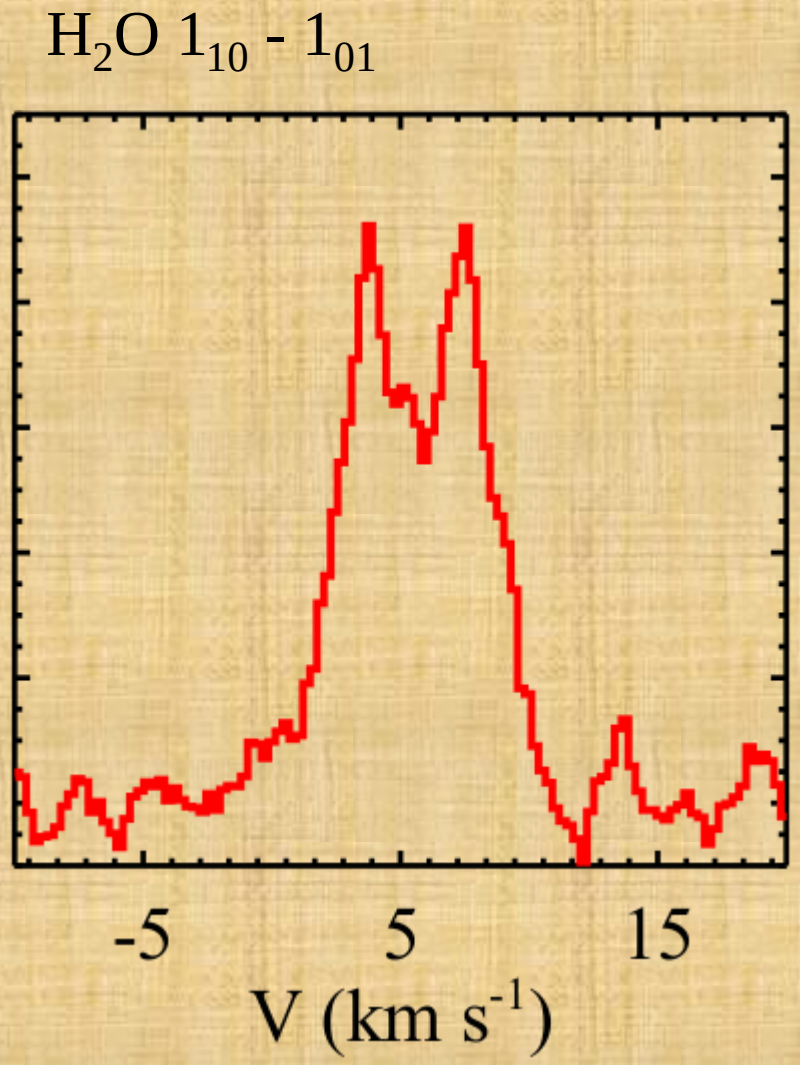
Molecular emission: T_{ex}, N

	T_{ex} (K)	N (cm^{-2})	r (au)
OH	100-300	10^{14} - 10^{15}	20-100
CO	300-900	10^{16} - 10^{18}	20-200
H_2O	100-300	10^{15} - 10^{19}	10-30

Cold H_2O

HD 100546

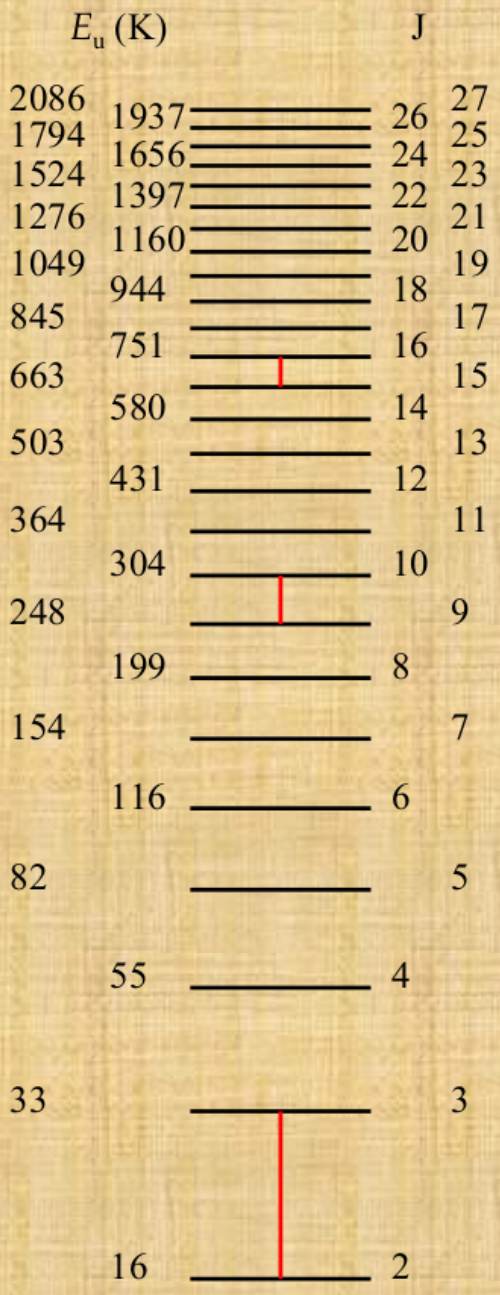
HD 163296



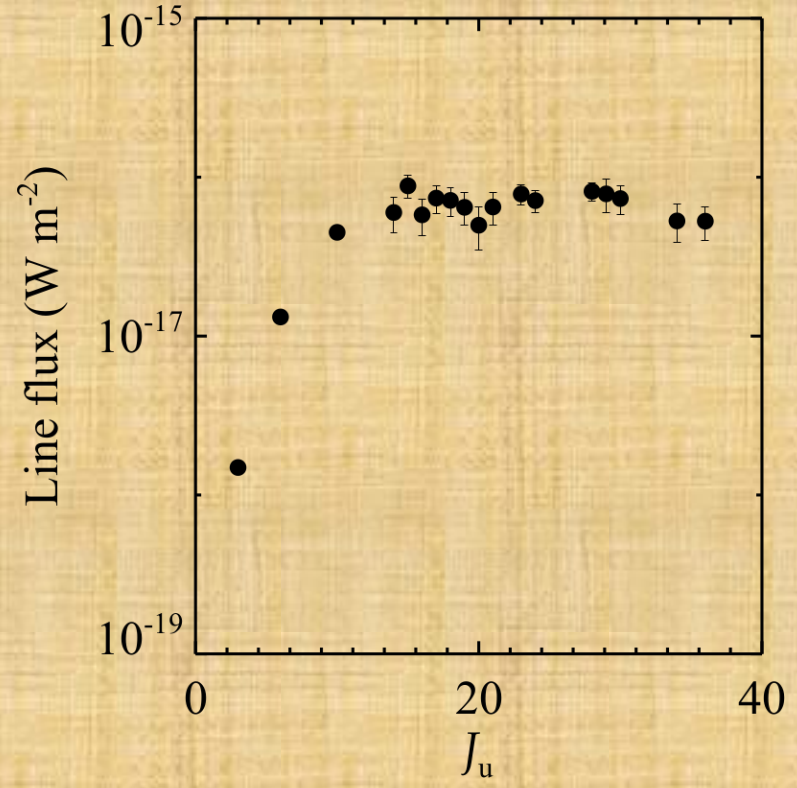
Hogerheijde+ to be submitted

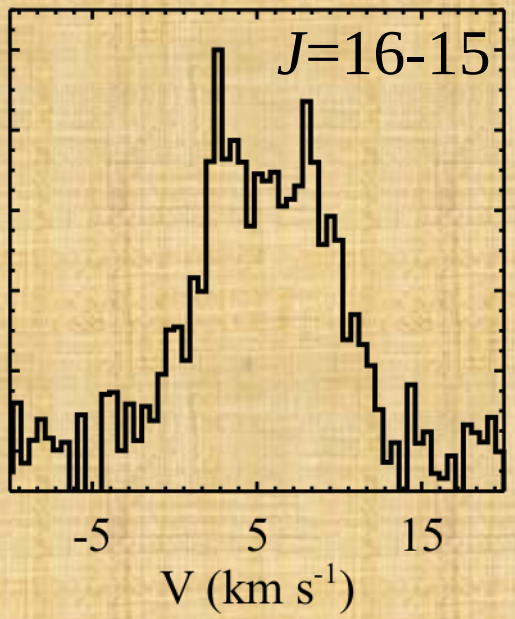
Gas temperature gradient

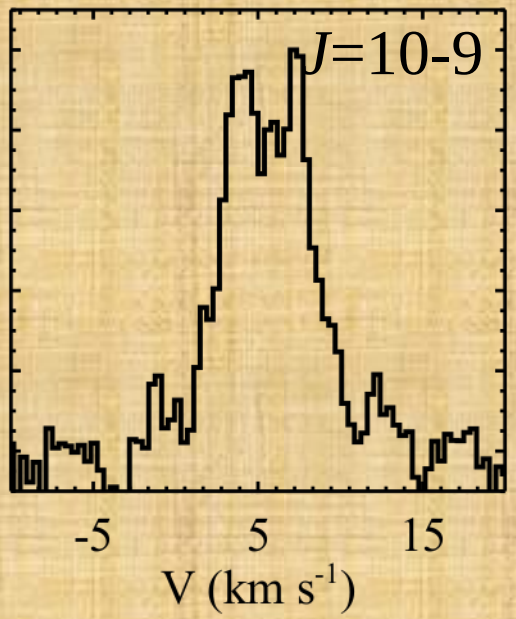
CO as thermometer

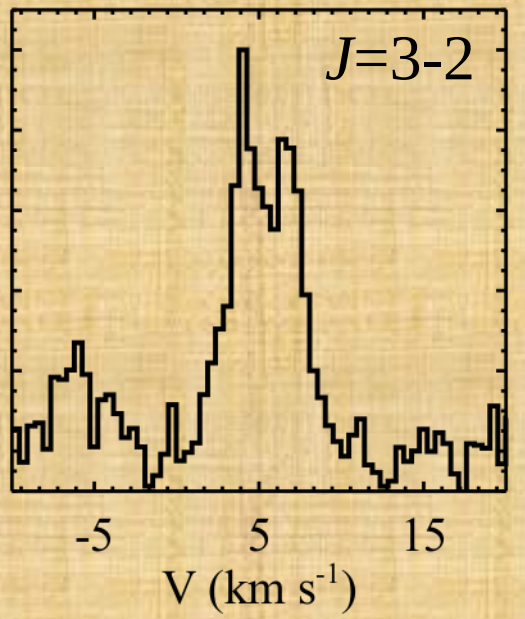


HD 100546 (2.5 $M_{\odot}$)



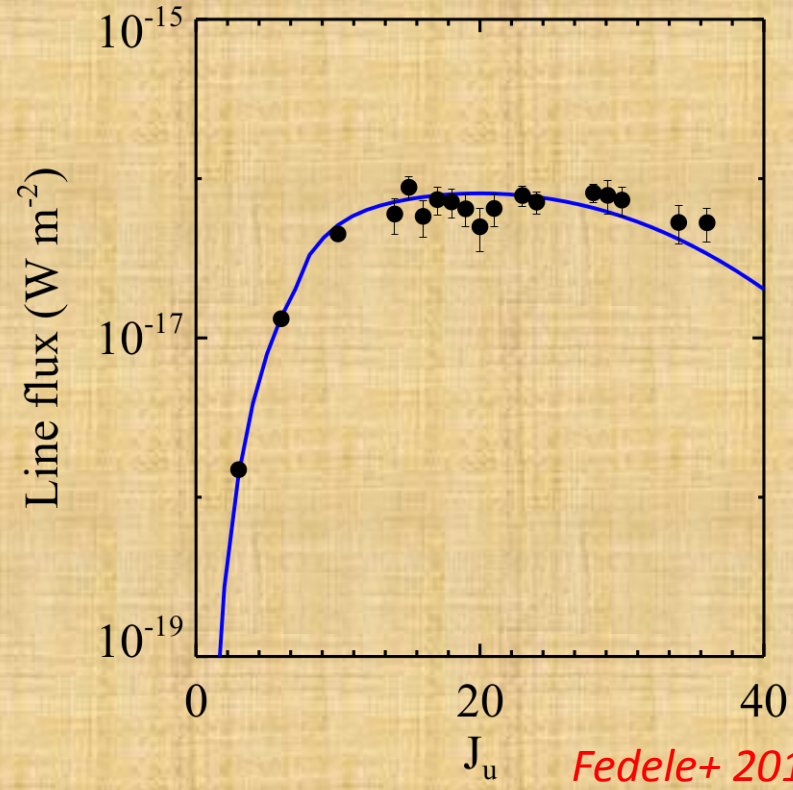




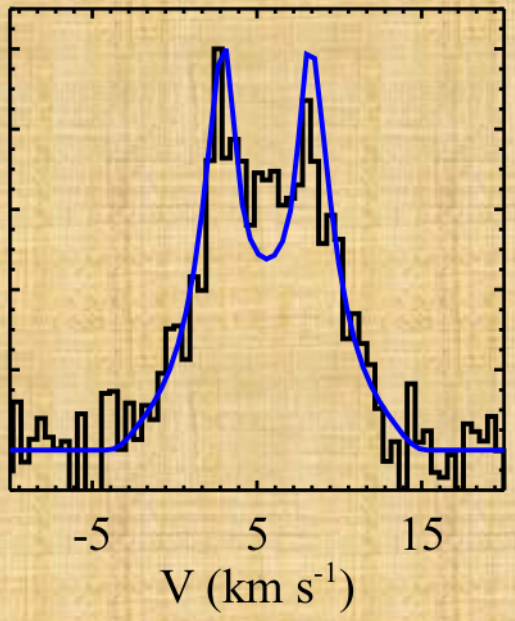


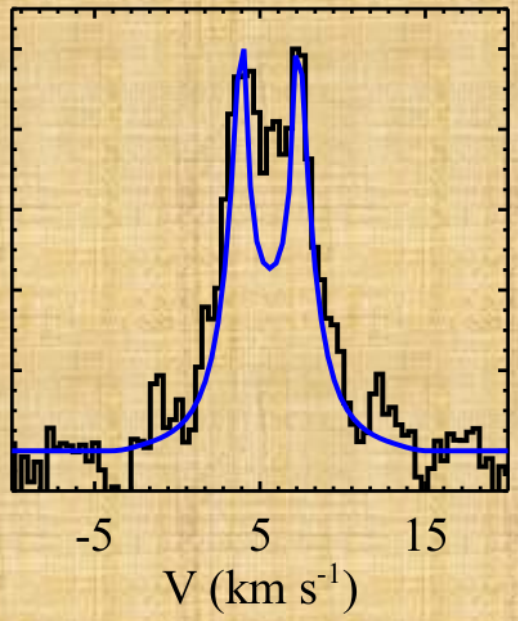
$$T(r) = T_0 \left(\frac{r}{r_0}\right)^{-p}$$

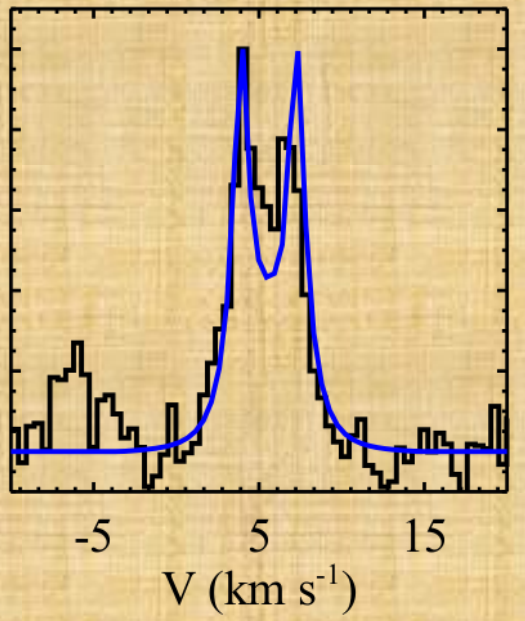
$$N(r) = N_0 \left(\frac{r}{r_0}\right)^{-q}$$



Fedele+ 2013b

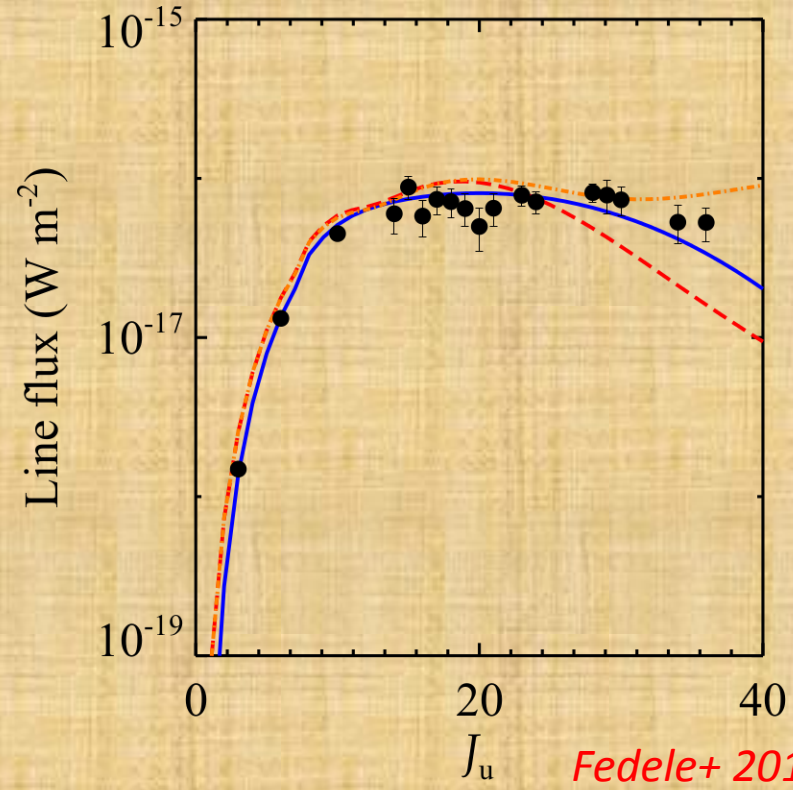




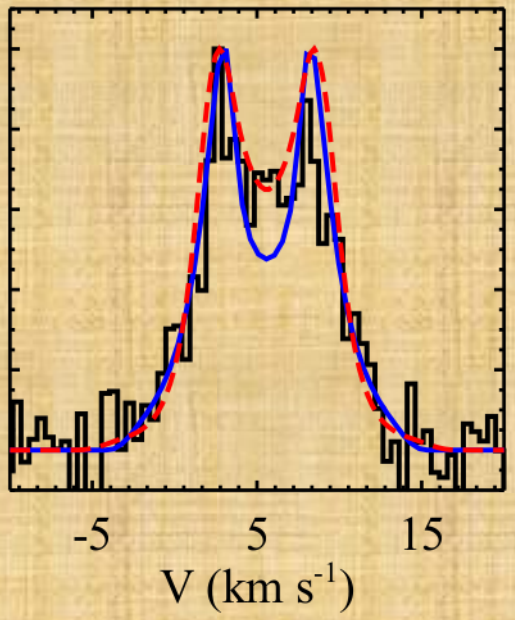


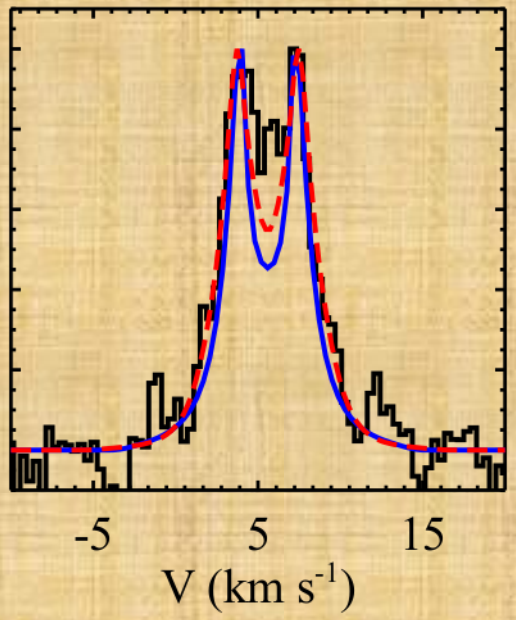
$$T(r) = T_0 \left(\frac{r}{r_0}\right)^{-p}$$

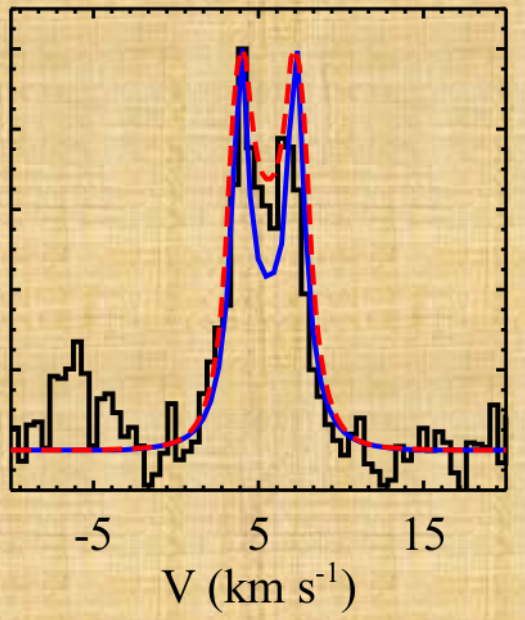
$$N(r) = N_0 \left(\frac{r}{r_0}\right)^{-q}$$

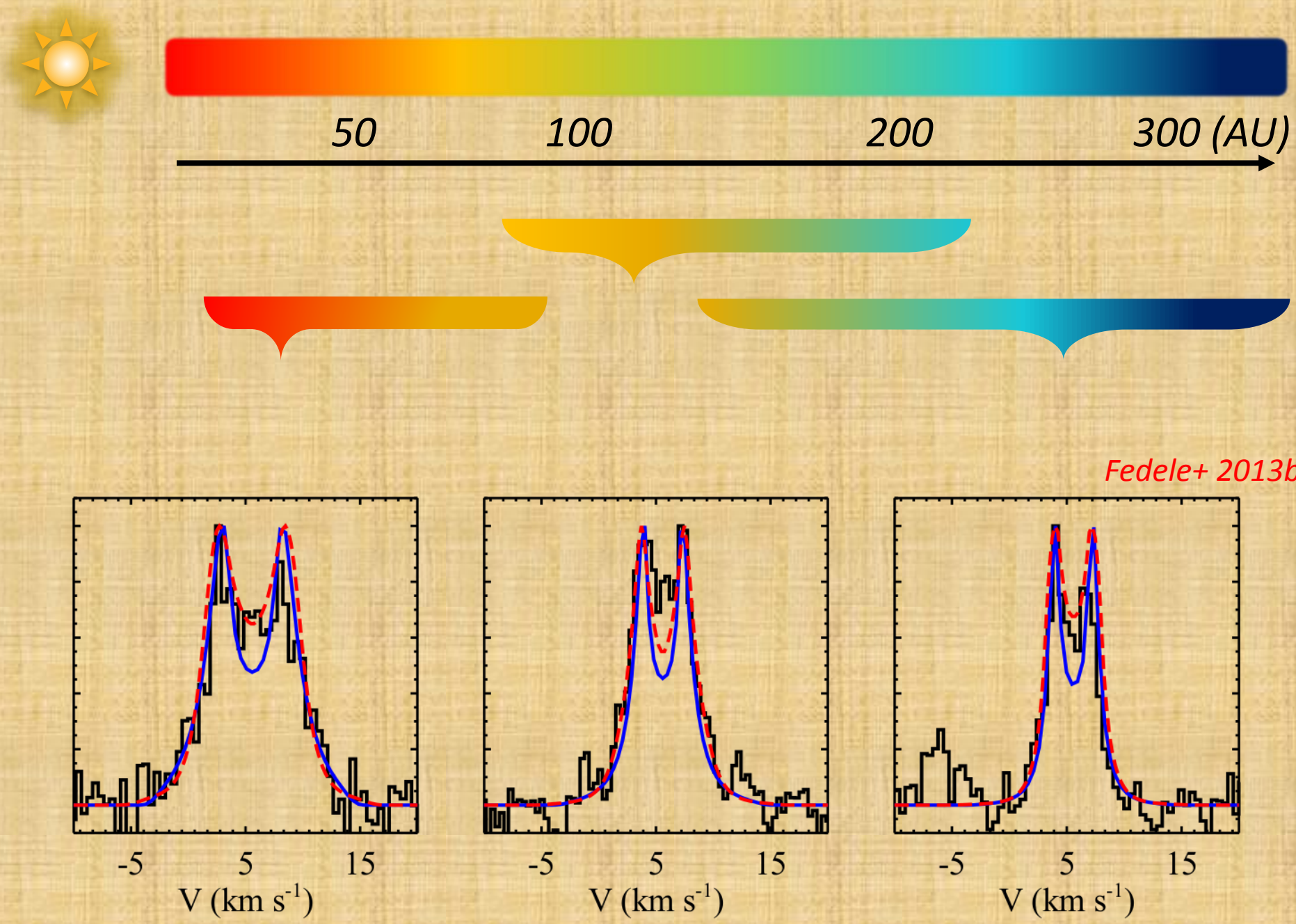


Fedele+ 2013b



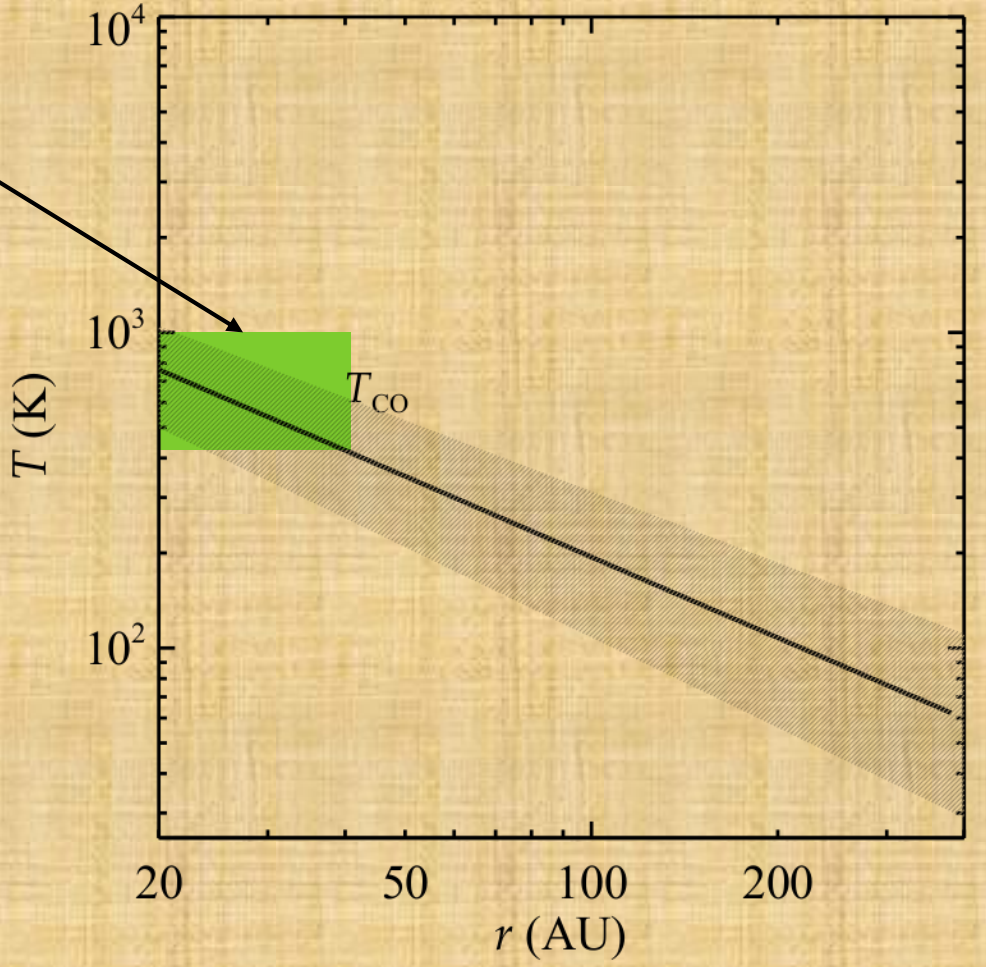





50
100
200
300 (AU)
Fedele+ 2013b
-5
5
15
V (km s-1)
-5
5
15
V (km s-1)
-5
5
15
V (km s-1)

CO v=2-1

Goto et al. ’12

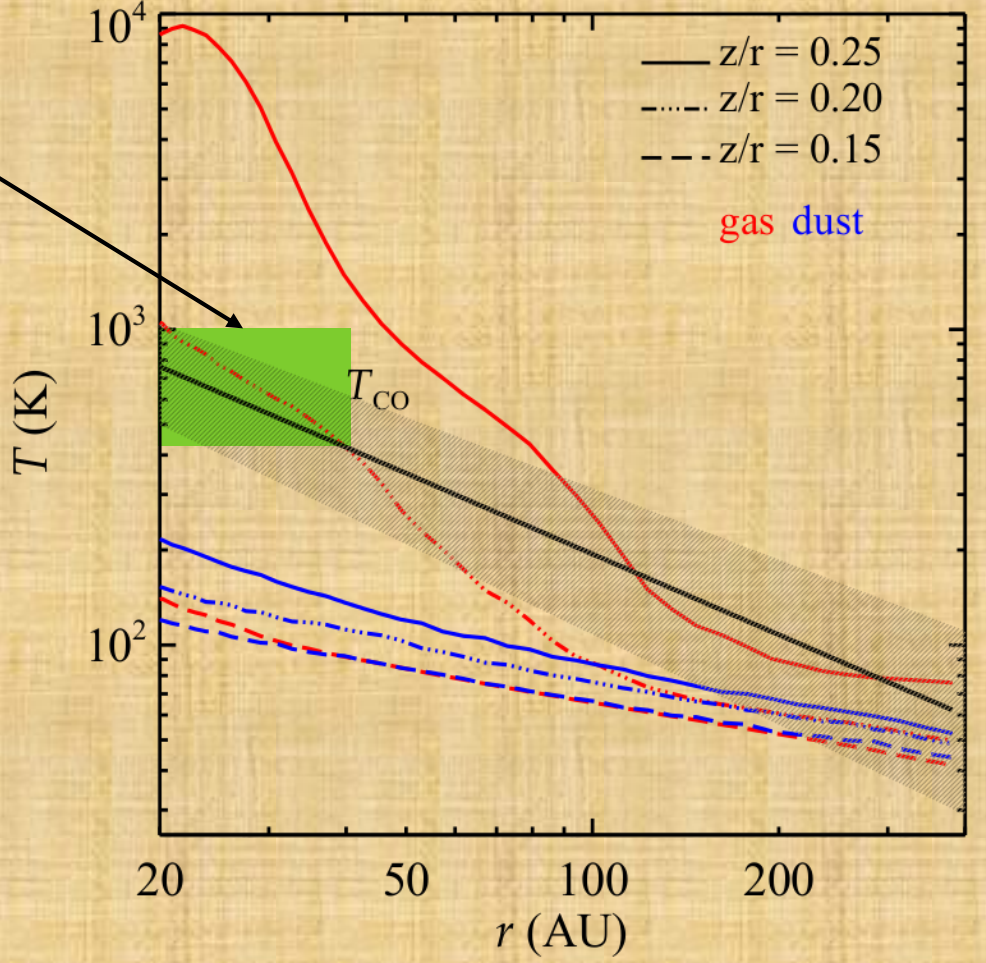


Fedele+ 2013b

$$T(r) \propto r^{-0.85}$$

CO v=2-1

Goto et al. '12



Model predictions

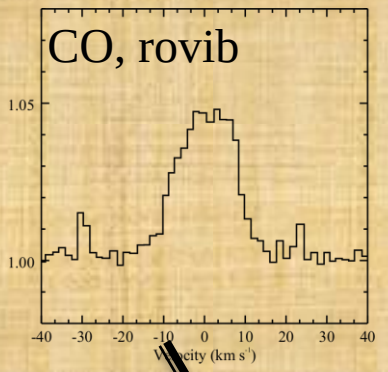
Bruderer et al. '12

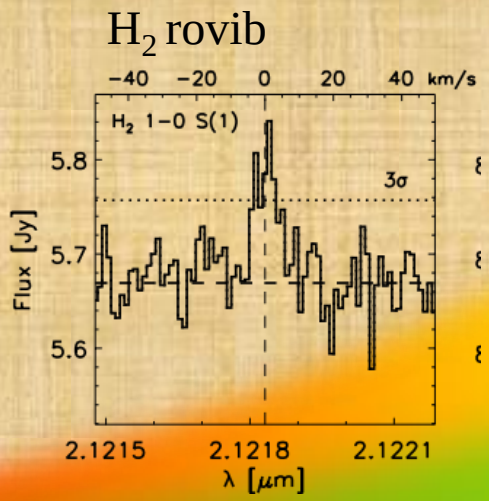
Fedele+ 2013b

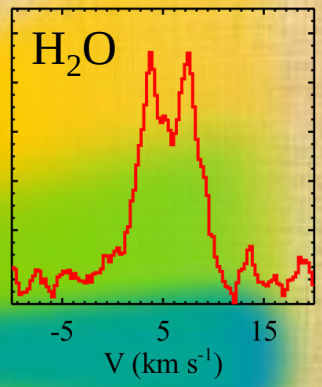
$$T(r) \propto r^{-0.85}$$

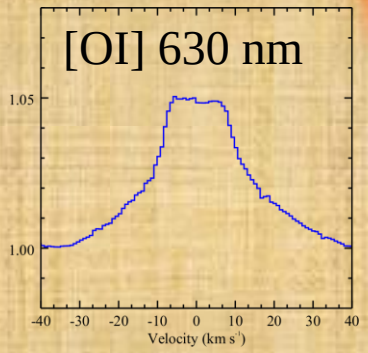
$$T_{gas} > T_{dust}$$

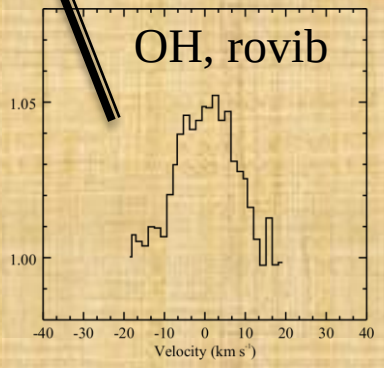
HD 100546

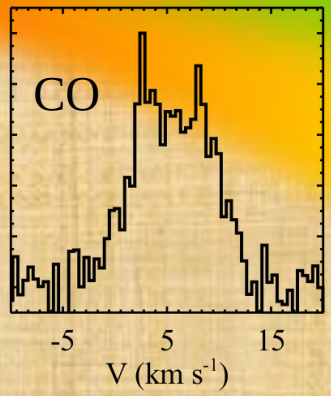

CO, rovib
1.05
1.00
-40 -30 -20 -10 0 10 20 30 40


H2 rovib
−40 −20 0 20 40 km/s
H2 1−0 S(1)
3σ
5.8
5.7
5.6
Flux [Jy]
2.1215
2.1218
2.1221
λ [μm]


H2O
-5
5
15
V (km s-1)

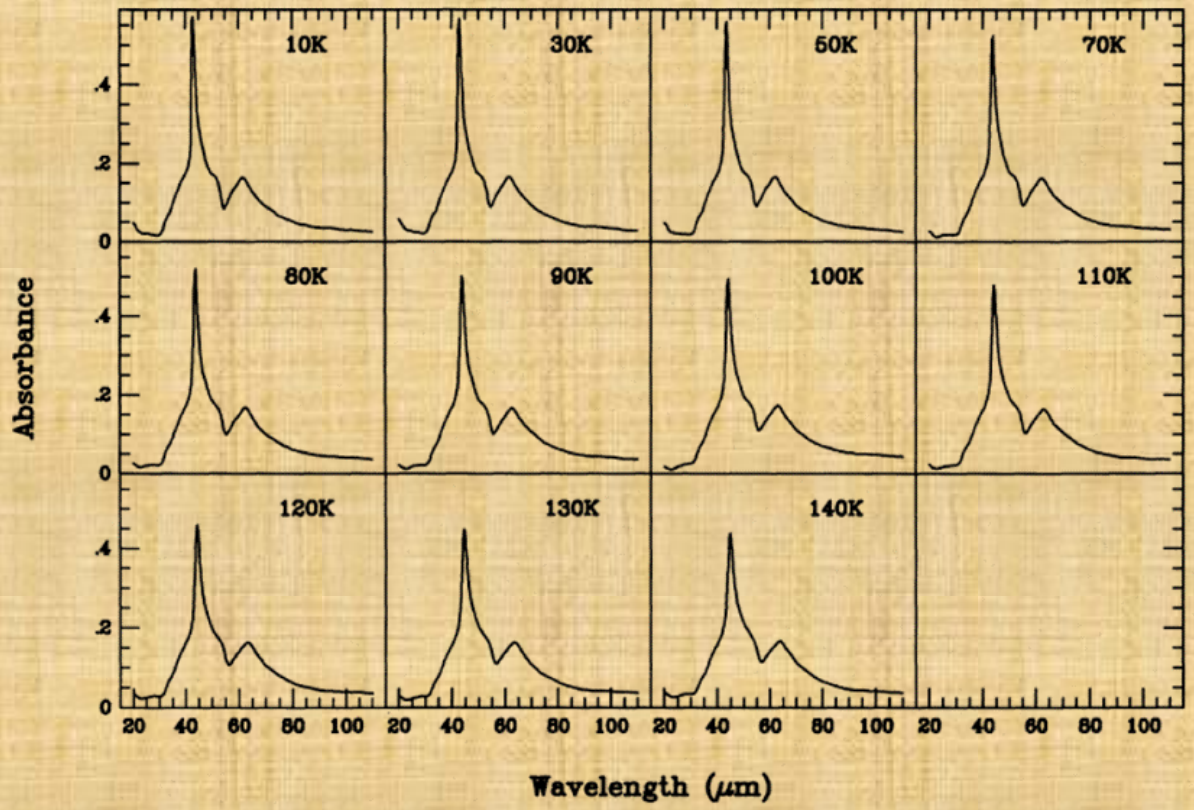

[OI] 630 nm
1.05
1.00
-40 -30 -20 -10 0 10 20 30 40
Velocity (km s-1)


OH, rovib
1.05
1.00
-40 -30 -20 -10 0 10 20 30 40
Velocity (km s-1)


CO
-5
5
15
V (km s-1)

H_2O ice (snow line) ?

McClure+ 2013, Bouwman in prep.



Smith+ 1994

SPICA