Star Formation Seminar
No. 261
#8 Boss — #12 Clark
October 24, 2014

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Collapse and Fragmentation of Magnetic Molecular Cloud Cores with the Enzo AMR MHD Code. II. Prolate and Oblate Cores,

A. P. Boss & S. A. Keiser

ApJ, 794, 44 (2014)

初期ガウス型密度分布，Oblate / Prolate

$$\rho_i(x, y, z) = \rho_o \, exp\left(-\left(\frac{x}{r_a}\right)^2 - \left(\frac{y}{r_b}\right)^2 - \left(\frac{z}{r_c}\right)^2\right),$$

$P = P(\rho)$ を仮定、理想 MHD (磁気散逸なし),

64^3 デカルト格子を基底としたAMR (低い角度分解能?)

初期磁場の強さを変える

Boss & Keiser 13,　初期一様,

Pseudo MHD (磁気圧だけ。磁気張力を無視)

結論: 磁束あたりの質量が臨界値の14倍あれば分裂

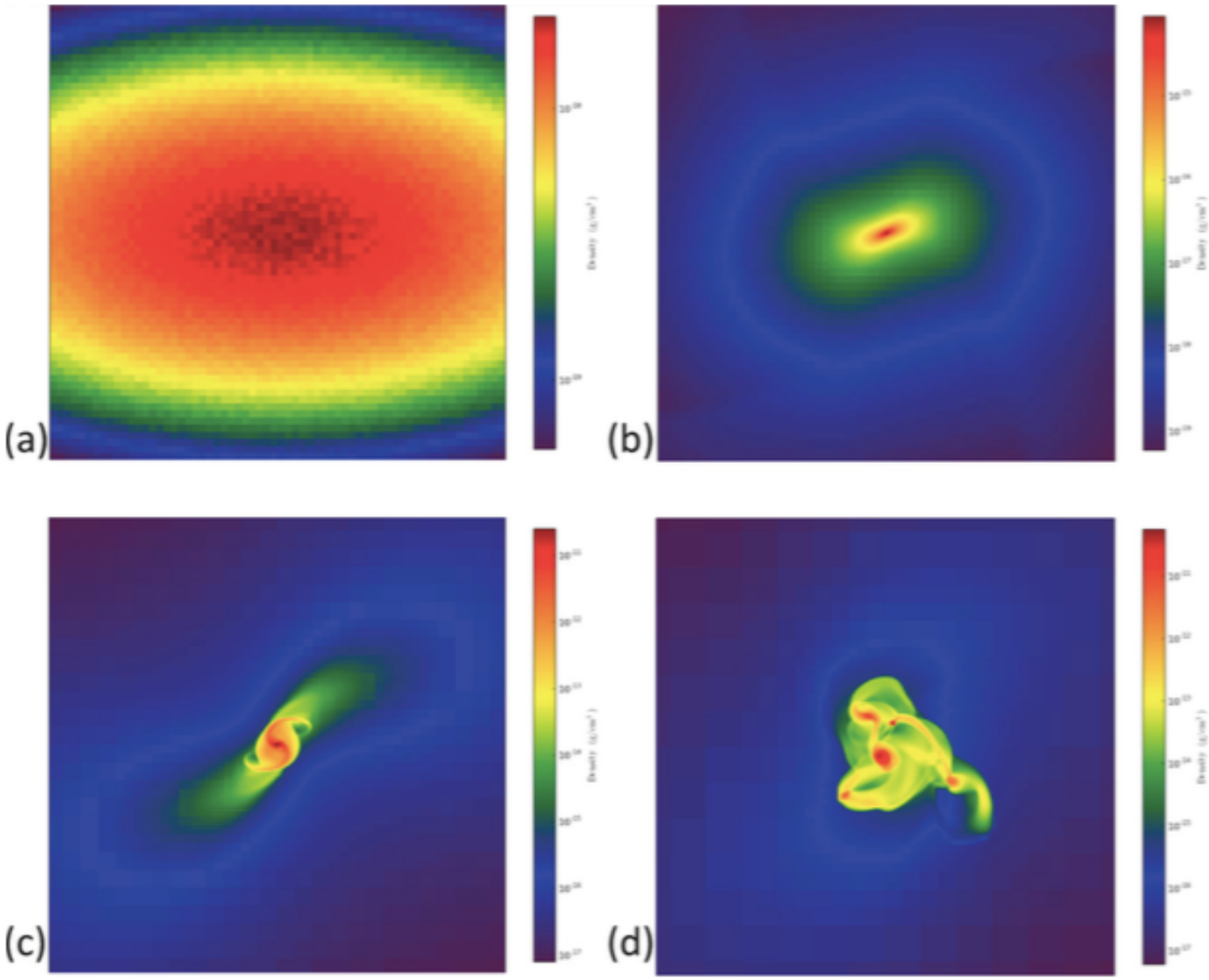
Prolate: 1.16:0.58:0.58

Table 1.

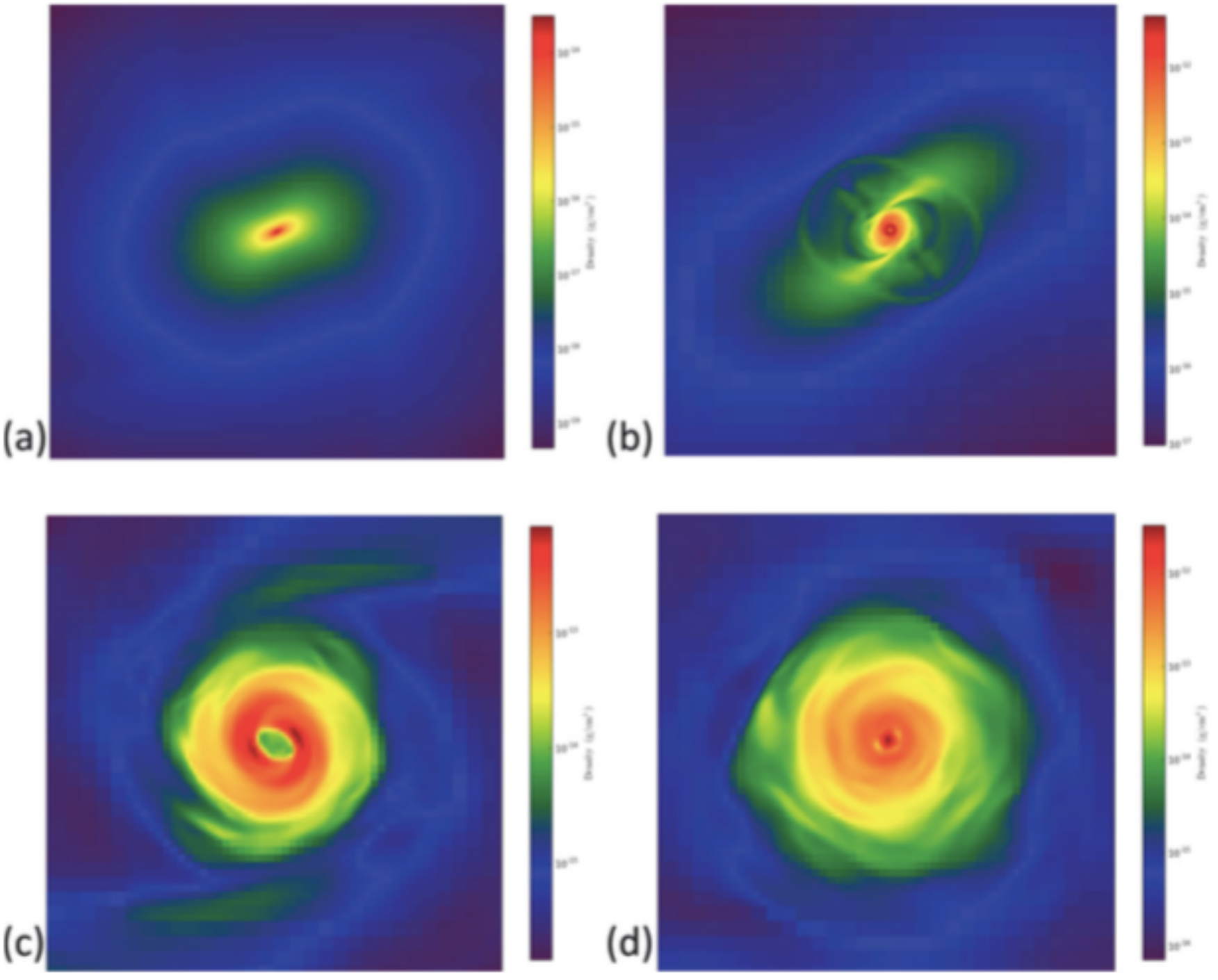
Model	Ω_i (rad s^{-1})	β_i	B_z (μG)	M/Φ	$t_f/t_{\rm ff}$	Result	Midplane
BPP2R	3.2×10^{-13}	10^{-1}	100.0	1.8	2.67	Single	z
BPP2A	1.0×10^{-13}	10^{-2}	100.0	1.8	1.68	Single	z
BPP2C	3.2×10^{-14}	10^{-3}	100.0	1.8	1.71	Single	z
BPP2E	1.0×10^{-14}	10^{-4}	100.0	1.8	1.64	Single	x
BLPP2R	3.2×10^{-13}	10^{-1}	50.0	3.6	1.86	Single	z
BLPP2A	1.0×10^{-13}	10^{-2}	50.0	3.6	1.52	Single	z
BLPP2C	3.2×10^{-14}	10^{-3}	50.0	3.6	1.52	Single	z
BLPP2E	1.0×10^{-14}	10^{-4}	50.0	3.6	1.47	Single	y
BMPP2R	3.2×10^{-13}	10^{-1}	25.0	7.2	2.34	Single	z
BMPP2A	1.0×10^{-13}	10^{-2}	25.0	7.2	1.62	Single	z
BMPP2C	3.2×10^{-14}	10^{-3}	25.0	7.2	1.61	Single	z
BMPP2E	1.0×10^{-14}	10^{-4}	25.0	7.2	1.60	Single	z
BNPP2R	3.2×10^{-13}	10^{-1}	12.5	14.4	2.76	Multiple	z
BNPP2A	1.0×10^{-13}	10^{-2}	12.5	14.4	2.17	Multiple	z
BNPP2C	3.2×10^{-14}	10^{-3}	12.5	14.4	1.92	Single	z
BNPP2E	1.0×10^{-14}	10^{-4}	12.5	14.4	1.92	Single	z
BNPP2R2	3.2×10^{-13}	10^{-1}	12.5	14.4	3.23	Binary	z
BNPP2A2	1.0×10^{-13}	10^{-2}	12.5	14.4	1.74	Single	z
BNPP2C2	3.2×10^{-14}	10^{-3}	12.5	14.4	1.64	Single	z
BNPP2E2	1.0×10^{-14}	10^{-4}	12.5	14.4	1.61	Single	z
BOPP2R	3.2×10^{-13}	10^{-1}	6.3	28.4	2.59	Multiple	z
BOPP2A	1.0×10^{-13}	10^{-2}	6.3	28.4	1.91	Multiple	z
BOPP2C	3.2×10^{-14}	10^{-3}	6.3	28.4	1.85	Multiple	z
BOPP2E	1.0×10^{-14}	10^{-4}	6.3	28.4	1.88	Multiple	z
PP2R	3.2×10^{-13}	10^{-1}	0.0	∞	2.11	Multiple	z
PP2A	1.0×10^{-13}	10^{-2}	0.0	∞	1.68	Multiple	z
PP2C	3.2×10^{-14}	10^{-3}	0.0	∞	1.66	Multiple	z
PP2E	1.0×10^{-14}	10^{-4}	0.0	∞	1.66	Multiple	z

Oblate: 1.16:1.16:0.58

Model	Ω_i (rad s^{-1})	β_i	B_z (μG)	M/Φ	$t_f/t_{\rm ff}$	Result
BMPO2R	3.2×10^{-13}	10^{-1}	25.0	11.4	2.03	Multiple
BMPO2A	1.0×10^{-13}	10^{-2}	25.0	11.4	1.39	Single
BMPO2C	3.2×10^{-14}	10^{-3}	25.0	11.4	1.36	Single
BMPO2E	1.0×10^{-14}	10^{-4}	25.0	11.4	1.62	Single
BNPO2R	3.2×10^{-13}	10^{-1}	12.5	22.8	2.38	Multiple
BNPO2A	1.0×10^{-13}	10^{-2}	12.5	22.8	1.51	Multiple
BNPO2C	3.2×10^{-14}	10^{-3}	12.5	22.8	1.50	Multiple
BNPO2E	1.0×10^{-14}	10^{-4}	12.5	22.8	1.55	Multiple
BOPO2R	3.2×10^{-13}	10^{-1}	6.3	44.9	2.15	Multiple
BOPO2A	1.0×10^{-13}	10^{-2}	6.3	44.9	1.37	Multiple
BOPO2C	3.2×10^{-14}	10^{-3}	6.3	44.9	1.50	Multiple
BOPO2E	1.0×10^{-14}	10^{-4}	6.3	44.9	1.42	Multiple
PO2R	3.2×10^{-13}	10^{-1}	0.0	∞	2.31	Multiple
PO2A	1.0×10^{-13}	10^{-2}	0.0	∞	1.48	Multiple
PO2C	3.2×10^{-14}	10^{-3}	0.0	∞	1.69	Multiple
PO2E	1.0×10^{-14}	10^{-4}	0.0	∞	1.62	Multiple



Prolate モデルの進化 (磁場なし)



弱い磁場の入ったモデル(prolate)

1. 臨界値の1/14 の弱い磁場なら分裂
2. 一様球の場合と結果はあまり変わらない
3. Sink Particle を採用すると最終的な星の数が減少
    A. 長い時間進化を追えるから
    B. Sink Particle は自転もせず、磁場も持たないから

NIR spectroscopy of the HAeBe star HD 100546: III. Further Evidence of an Orbiting Companion?

S. D. Brittain et al.

ApJ, 791, 136

Herbig Be star HD 100546

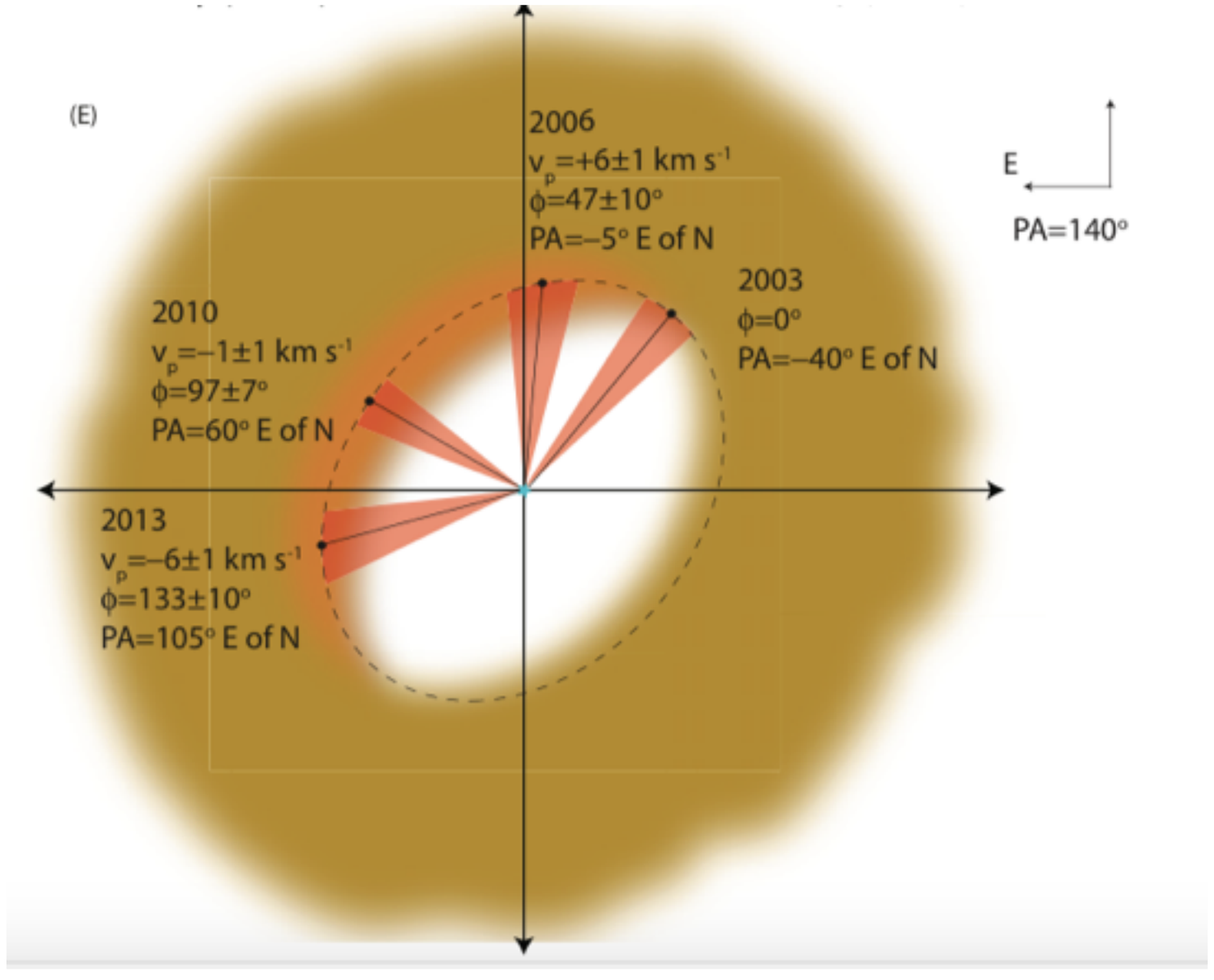
97 ± 4 pc (van Leeuwen 2007)

~3–10 Myr (Manoj et al. 2006; van den Ancker et al. 1997)

Transitional Disk

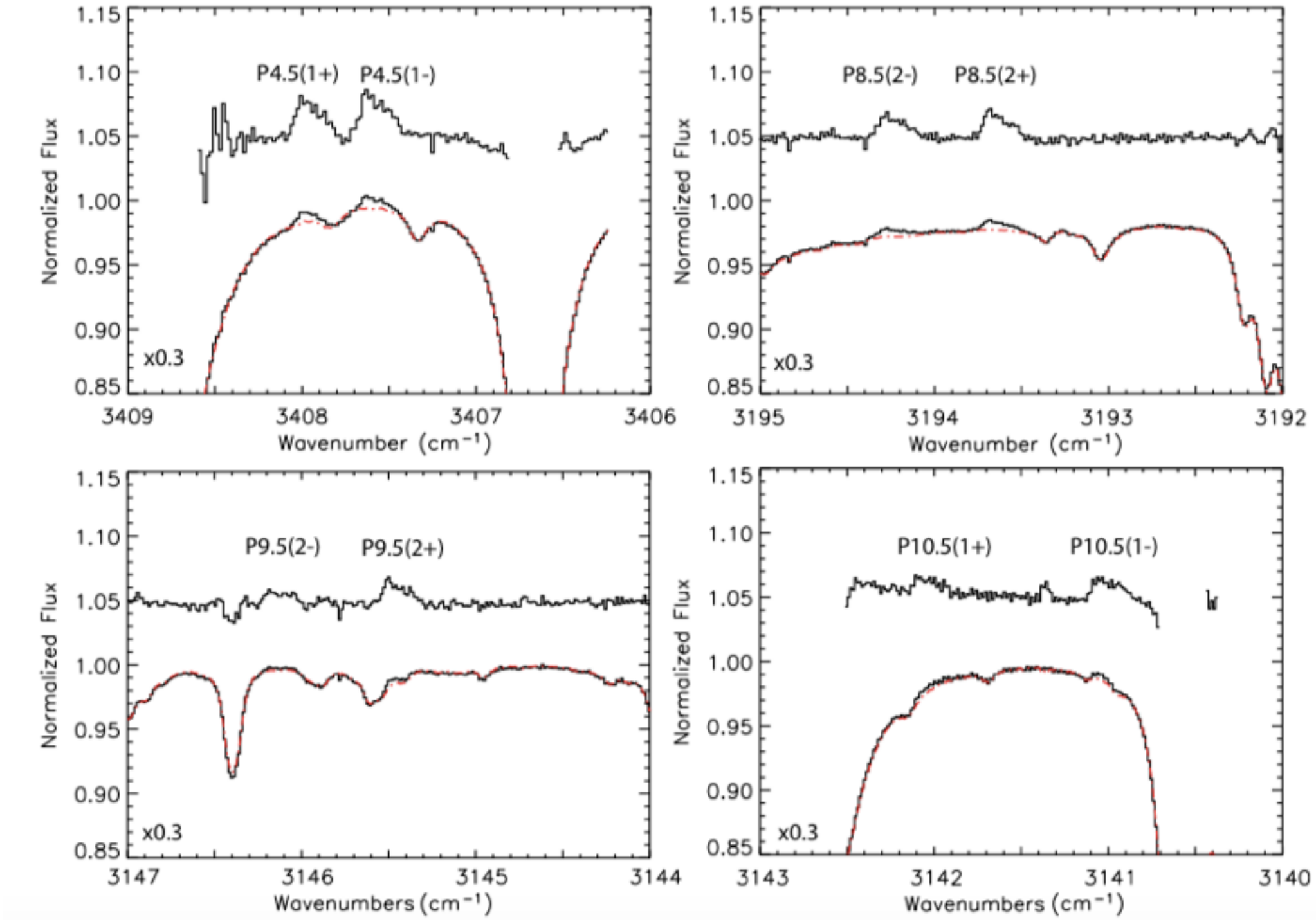
CO, OH lines (L-band, 3μm 帯, M-band 5μm, 振動)

CRIRES (VLT)



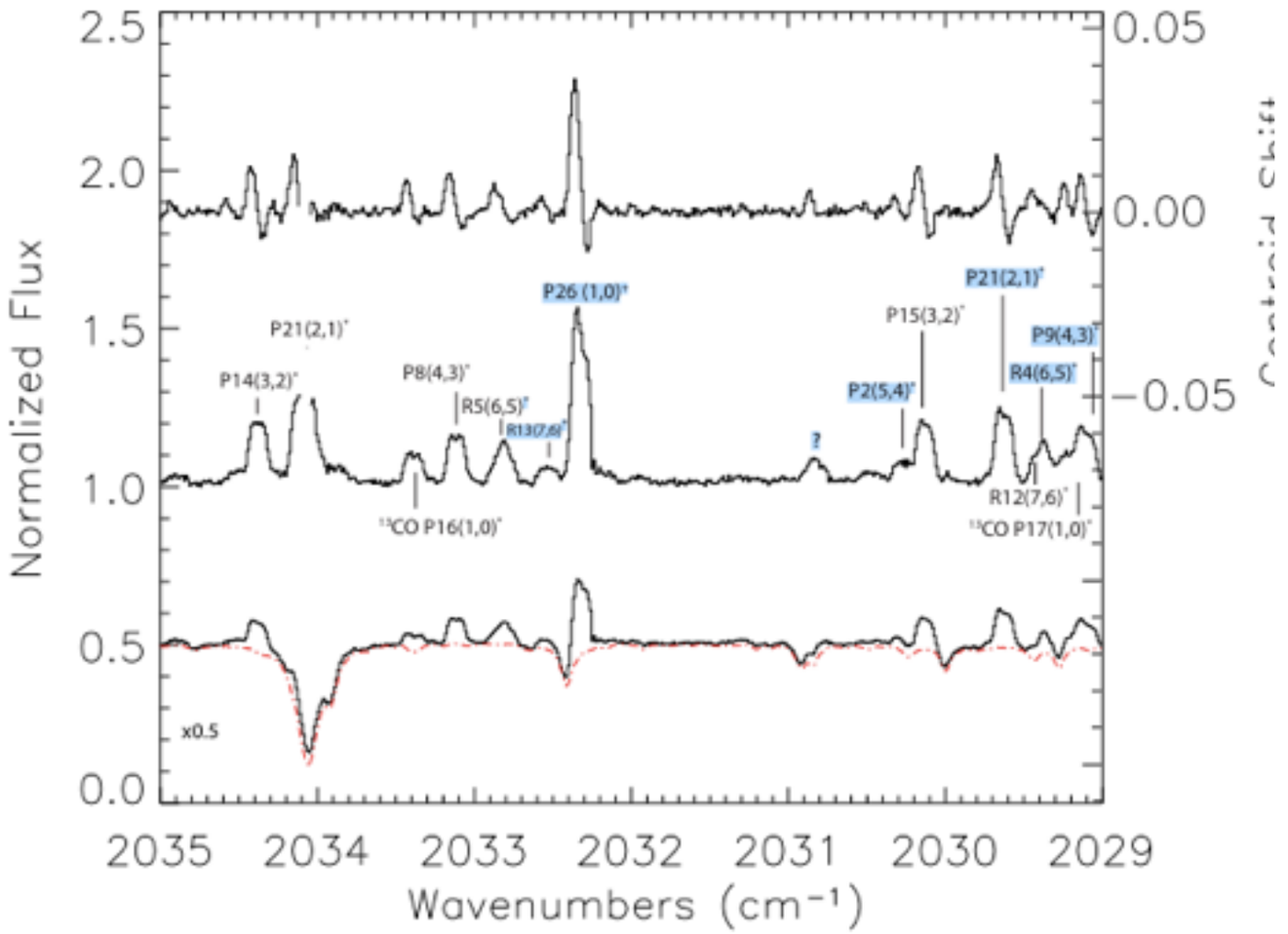
Wall の内側を 伴星が周回している

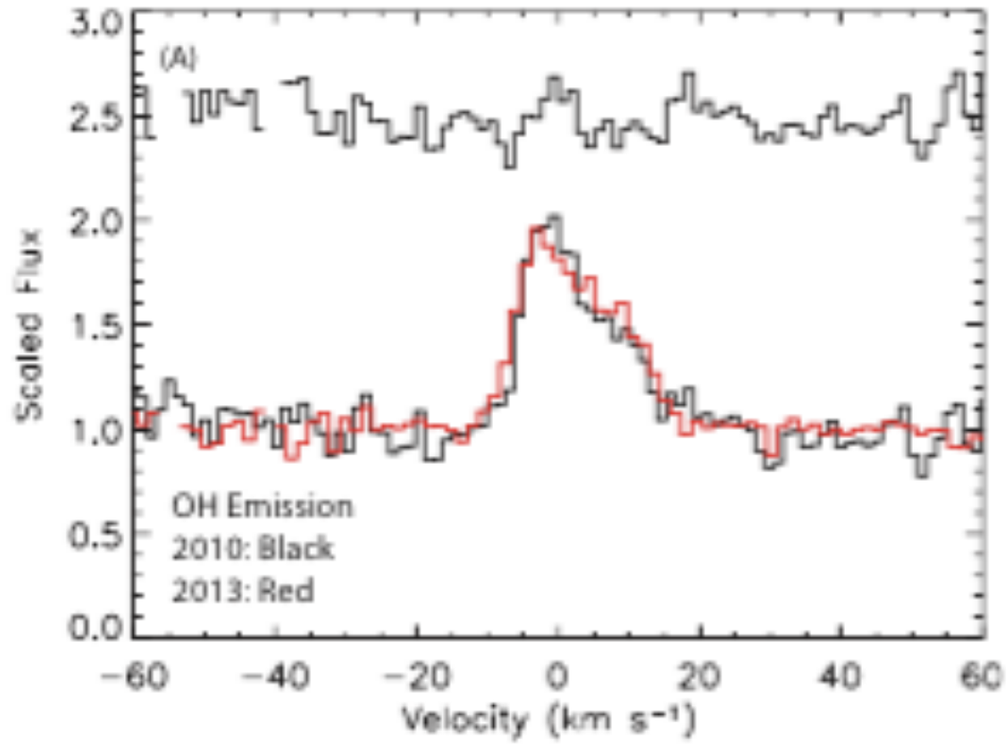
L-band OH line $T = 1060 \pm 40$ K

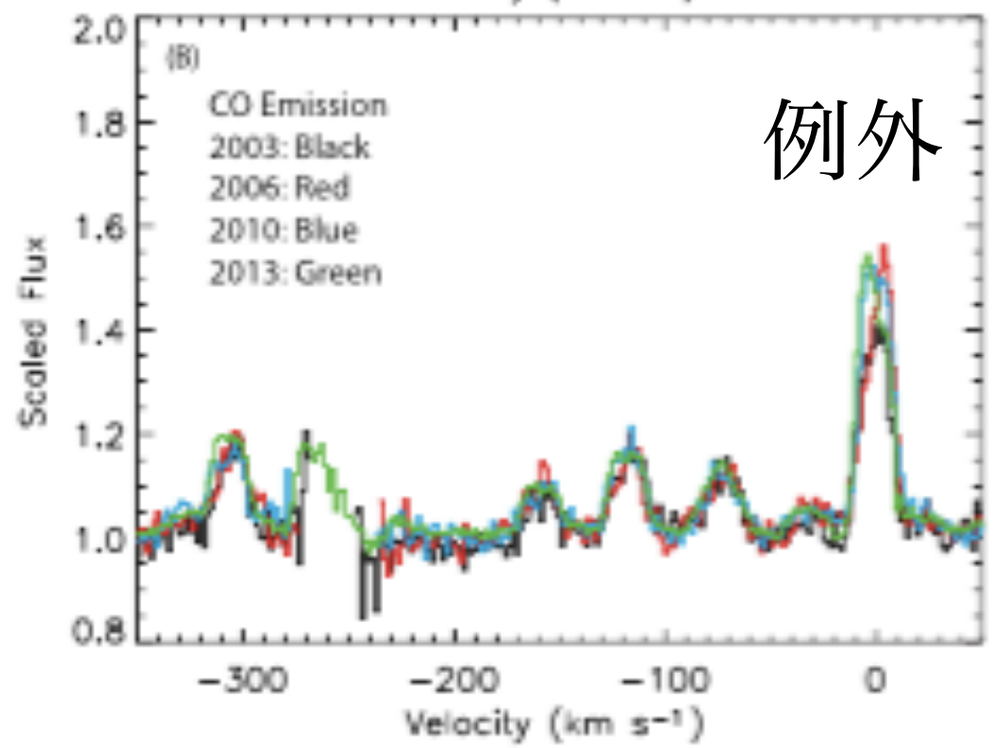


P electric dipole transition

M-band CO

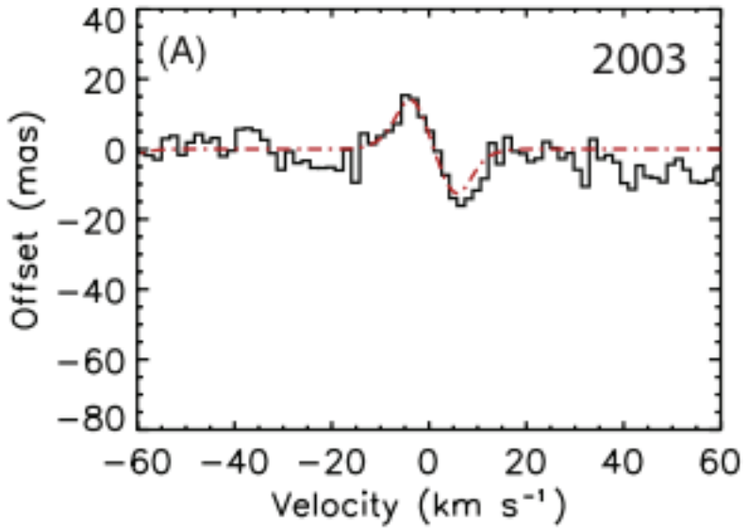


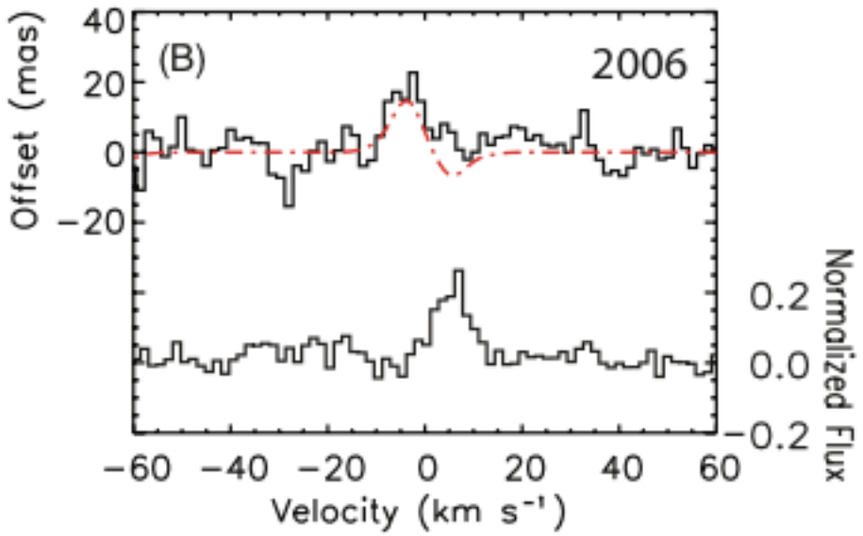


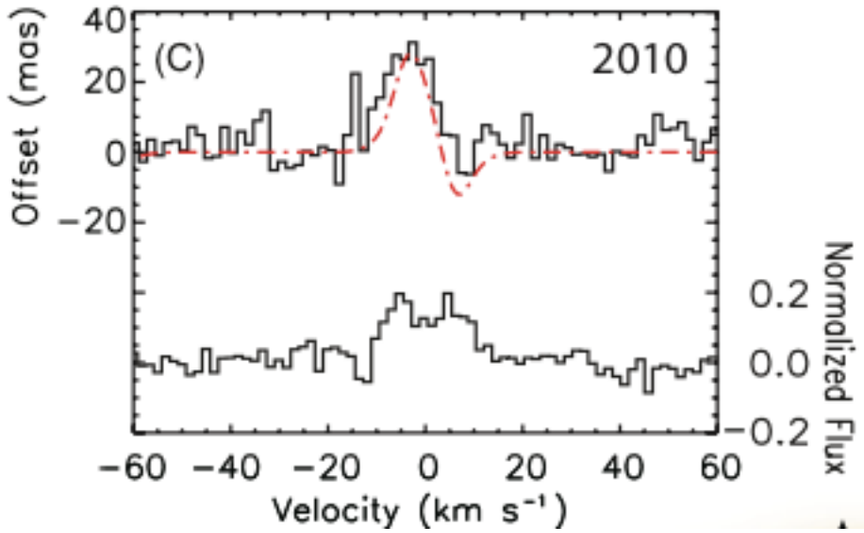


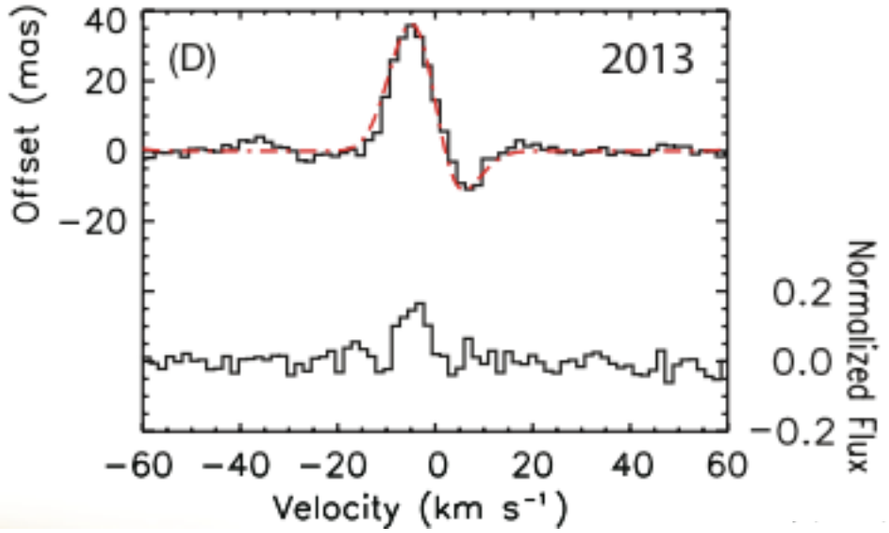
例外

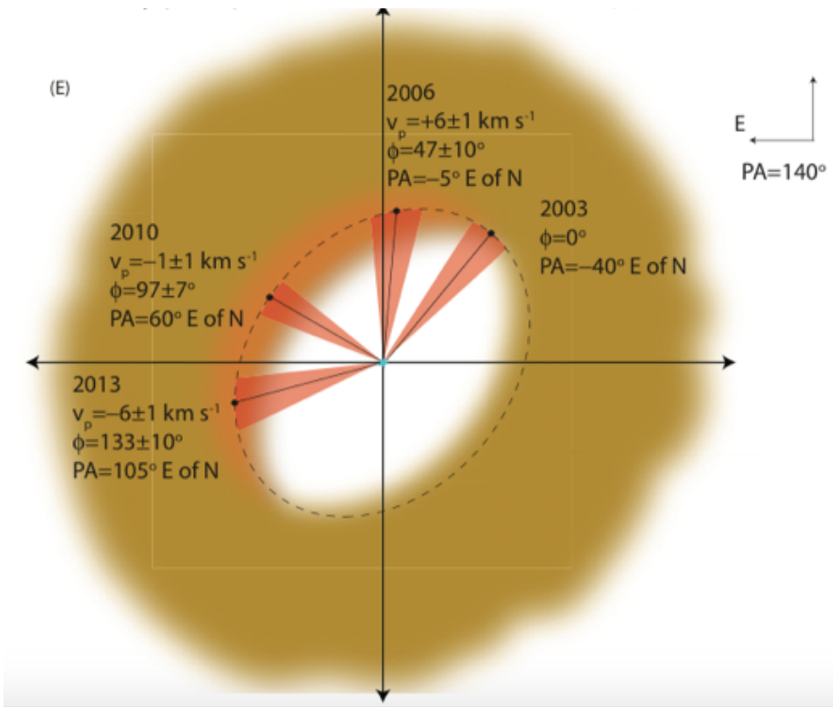
EWは変化するが形は変わらず


(A)
2003
Offset (mas)
Velocity (km s⁻¹)


(B)
2006
Offset (mas)
Velocity (km s⁻¹)
Normalized Flux


(C)
2010
Offset (mas)
Velocity (km s⁻¹)
Normalized Flux

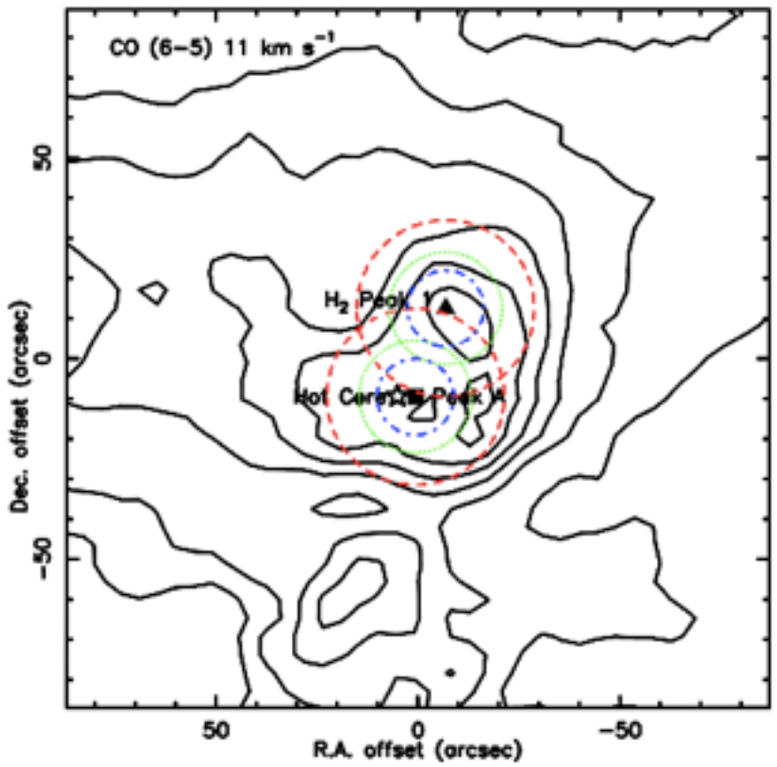

(D)
2013
Offset (mas)
Velocity (km s⁻¹)
Normalized Flux


(E)
2006
v_p=+6±1 km s⁻¹
ϕ=47±10°
PA=–5° E of N
2003
ϕ=0°
PA=–40° E of N
2010
v_p=–1±1 km s⁻¹
ϕ=97±7°
PA=60° E of N
2013
v_p=–6±1 km s⁻¹
ϕ=133±10°
PA=105° E of N
E
PA=140°

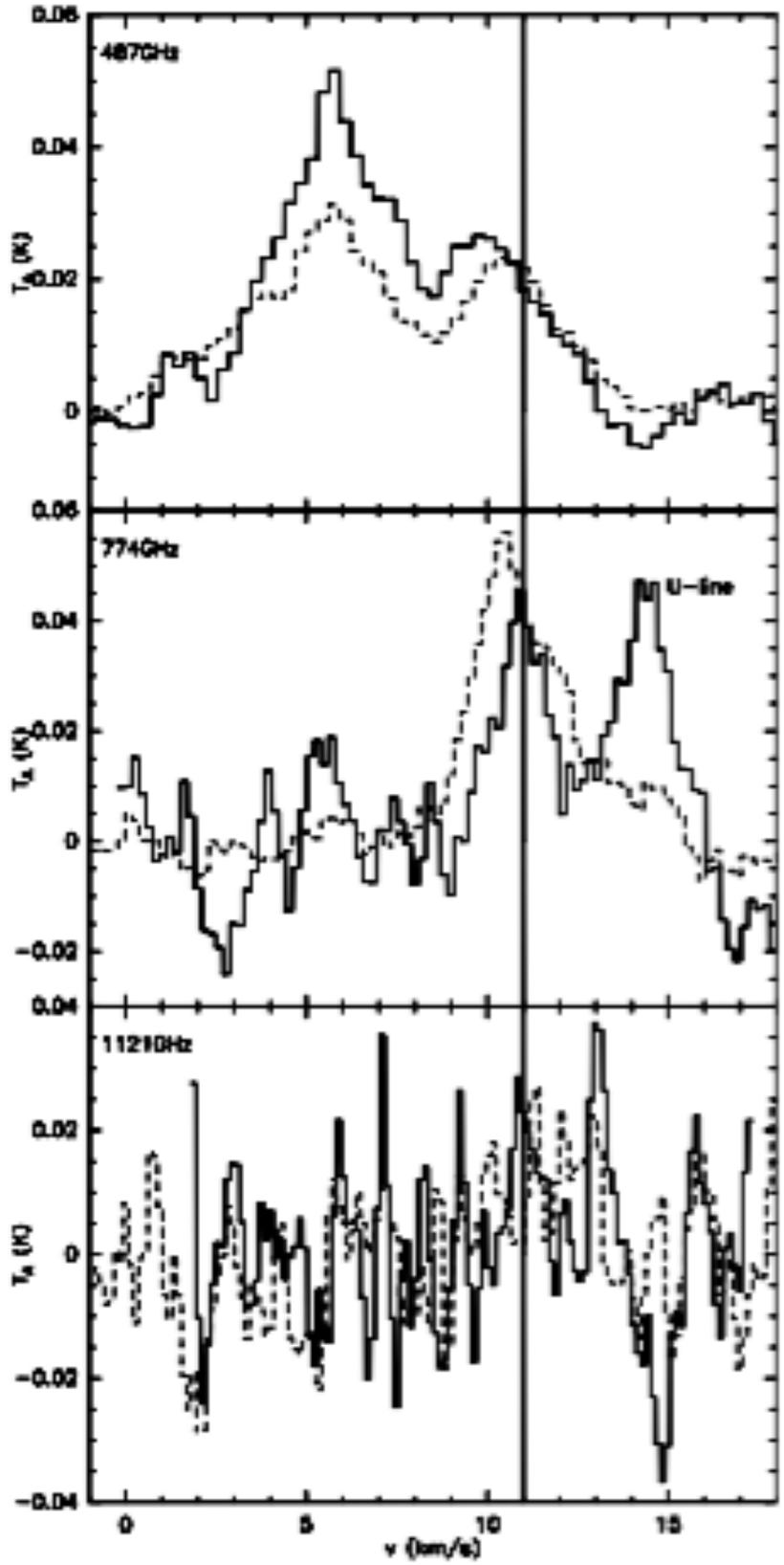
Herschel HIFI Observations of O2 Toward Orion: Special Conditions for Shock Enhanced Emission

Jo-Hsin Chen et al.

Ap. J., 793, 111 (2014)



Frequency[a] (MHz)	Transition[a]	E_u[a] (K)
487249.38	$N = 3–1, J = 3–2$	26
773839.69	$N = 5–3, J = 4–4$	61
1120715.04	$N = 7–5, J = 6–6$	115



Peak Aで受かった

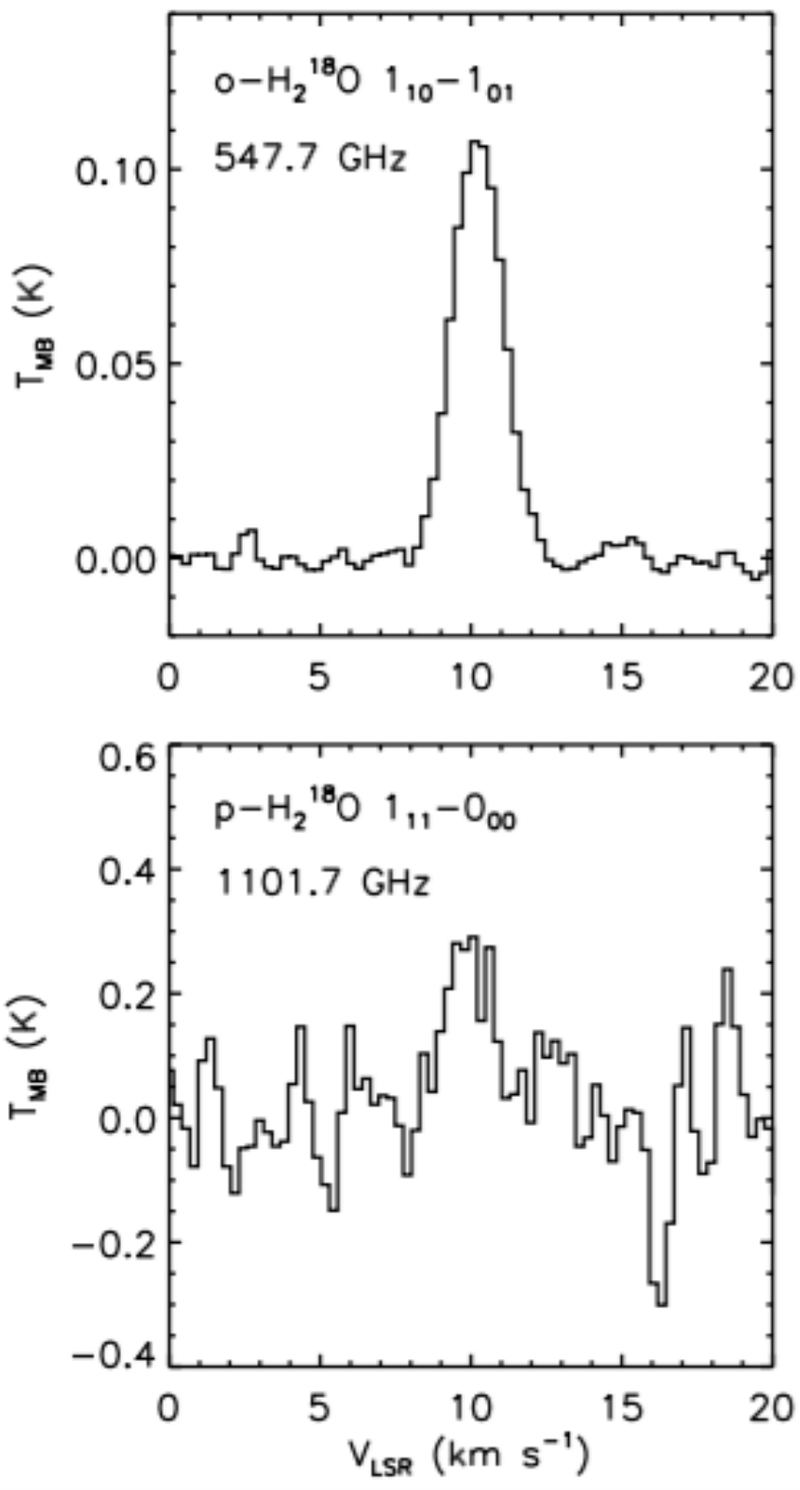
A non-equilibrium ortho-to-para ratio of water in the Orion PDR

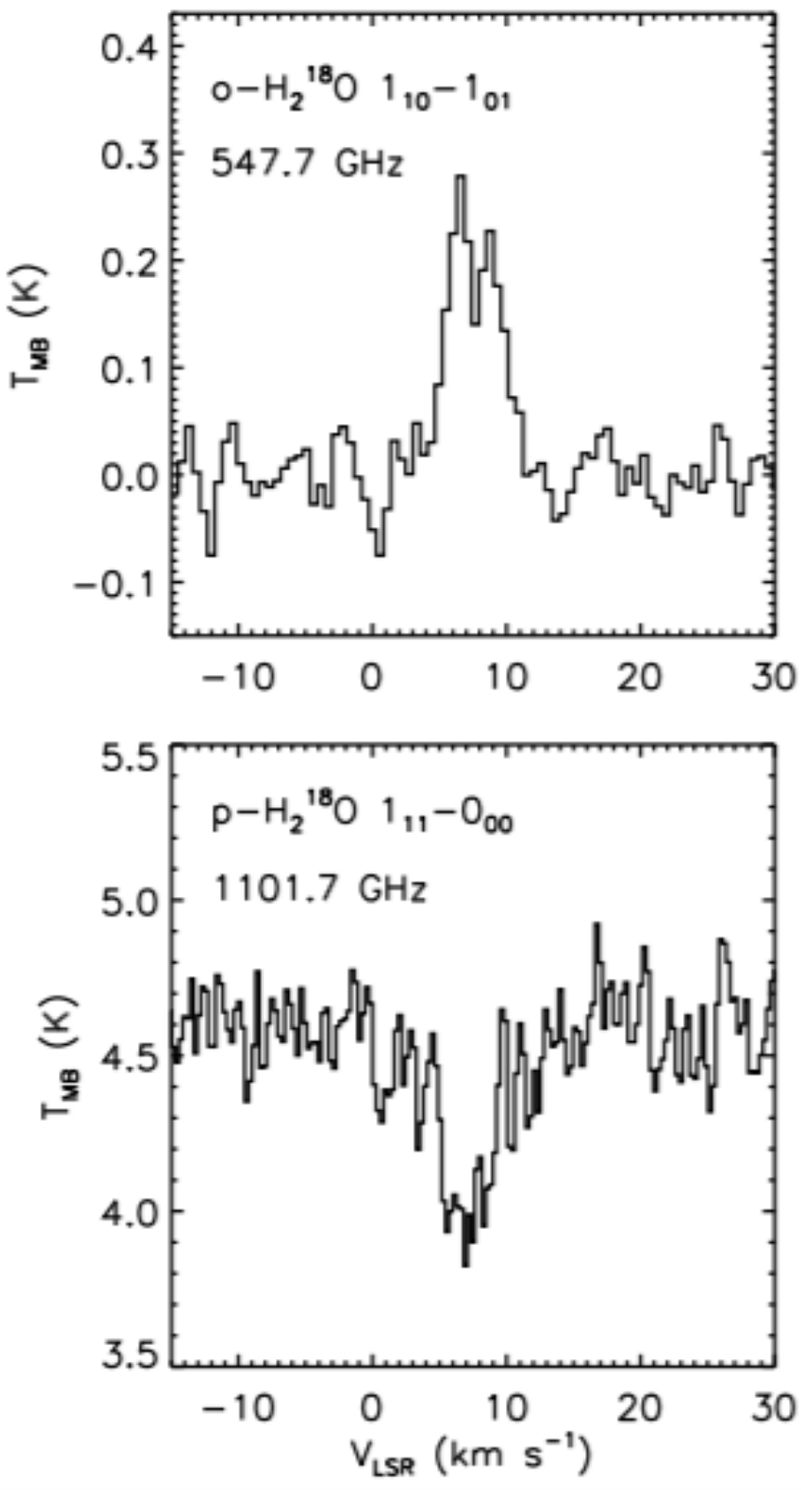
Y. Choi et al.

to appear in A&Ap Letter, 2014arXiv1409.1600C

Source	Molecule	Transition	ν (GHz)	E_{up} (K)	T_{sys} (K)	t_{int} (min)	Beam ($''$)	η_{mb}	δv (MHz)	rms (mK)
Orion Bar	o-$H_2{}^{18}O$	$1_{10} - 1_{01}$	547.676	60.5	63	88	38.7	0.75	0.48	2.67
	p-$H_2{}^{18}O$	$1_{11} - 0_{00}$	1101.698	53.4	350	56	19.2	0.74	1.1	102
Orion S	o-$H_2{}^{18}O$	$1_{10} - 1_{01}$	547.676	60.5	71	7.4	38.7	0.75	1.1	26
	p-$H_2{}^{18}O$	$1_{11} - 0_{00}$	1101.698	53.4	366	10	19.2	0.74	1.1	121

Source	Molecule	Transition	$\int T_{MB} dV$ (K km s^{-1})	V_{LSR} (km s^{-1})	ΔV (km s^{-1})	T_{MB} (K)
Orion Bar	o-$H_2{}^{18}O$	$1_{10} - 1_{01}$	0.23 (0.01)	10.22 (0.01)	1.93 (0.03)	0.11
	p-$H_2{}^{18}O$	$1_{11} - 0_{00}$	0.56 (0.12)	9.91 (0.19)	1.84 (0.48)	0.29
Orion S	o-$H_2{}^{18}O$	$1_{10} - 1_{01}$	1.17 (0.06)	7.45 (0.13)	4.66 (0.27)	0.23
	p-$H_2{}^{18}O$	$1_{11} - 0_{00}$	3.48 (0.27)	7.05 (0.18)	5.53 (0.64)	-0.59[a]


o−H2 18O 1 10−1 01
547.7 GHz
p−H2 18O 1 11−0 00
1101.7 GHz
TMB (K)
VLSR (km s−1)


o−H2 18O 1 10−1 01
547.7 GHz
p−H2 18O 1 11−0 00
1101.7 GHz
TMB (K)
VLSR (km s−1)

para がとても弱い

On column density thresholds and the star formation rate

P. C. Clark & S. C. O. Glover

MNRAS, 444, 2306-2414 (2014)

Kennicutt-Schmidt 則

i)　星形成が起こる平均面密度に下限があるか

ii) ある平均面密度に到達すると必ず星が生まれるのか

iii)　面密度は星形成率に影響を与えるのか

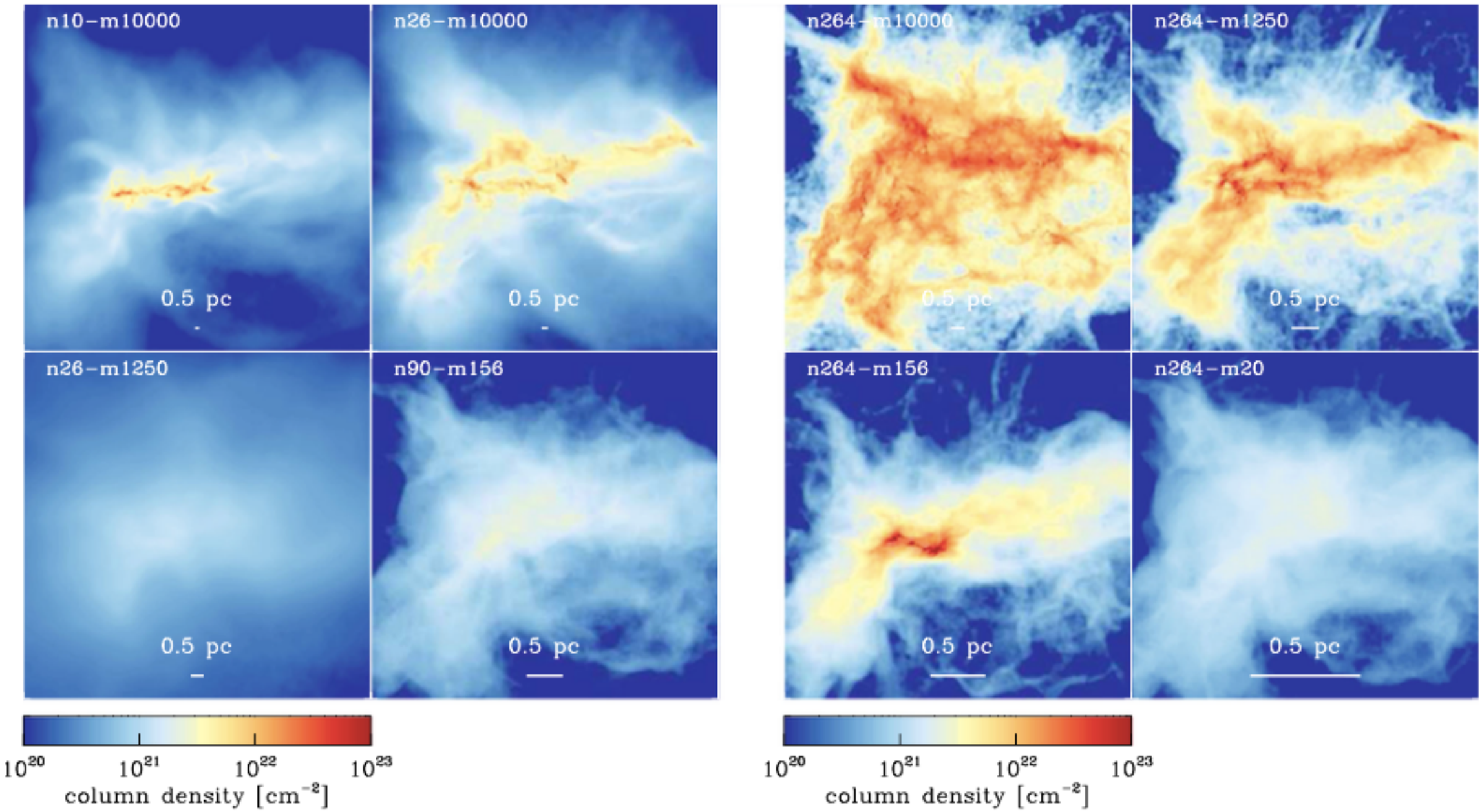
Gadget-2 SPH + 加熱・冷却 (line)

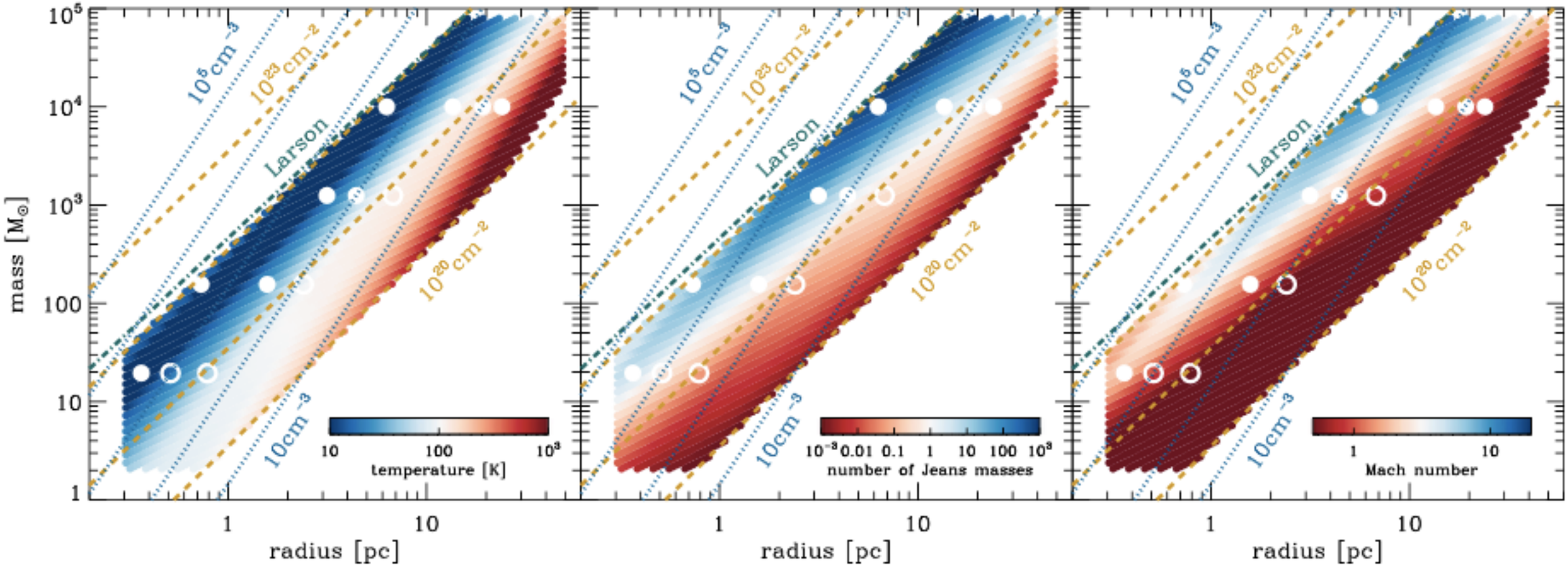
$n > 10^7$ cm^{-3} になったら星が生まれる

外圧 $P_{\rm ext}$

$M_{\rm cloud}$= 10^4, 1250, 156, 20 $M_{\rm o}$

一様密度球(+乱流)


n10−m10000
n26−m10000
n264−m10000
n264−m1250
n26−m1250
n90−m156
n264−m156
n264−m20
0.5 pc
10^{20}
10^{21}
10^{22}
10^{23}
column density [cm^{-2}]



i) 10^{21} cm^{-2} 以下では星形成が起こらない

ii) 10^{3} M_o 以下では 10^{21} cm^{-2} 以下の星を生まない雲が存在

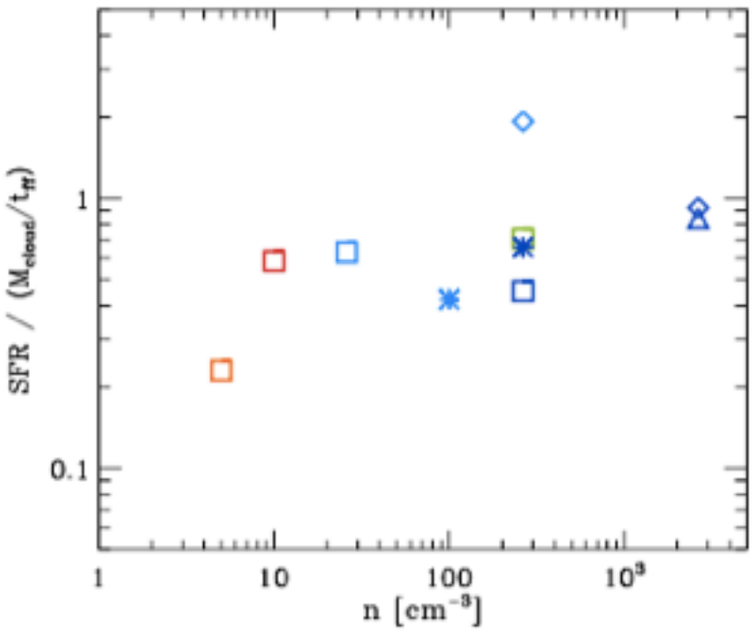
iii) 星を生まない雲のPDFは狭い。

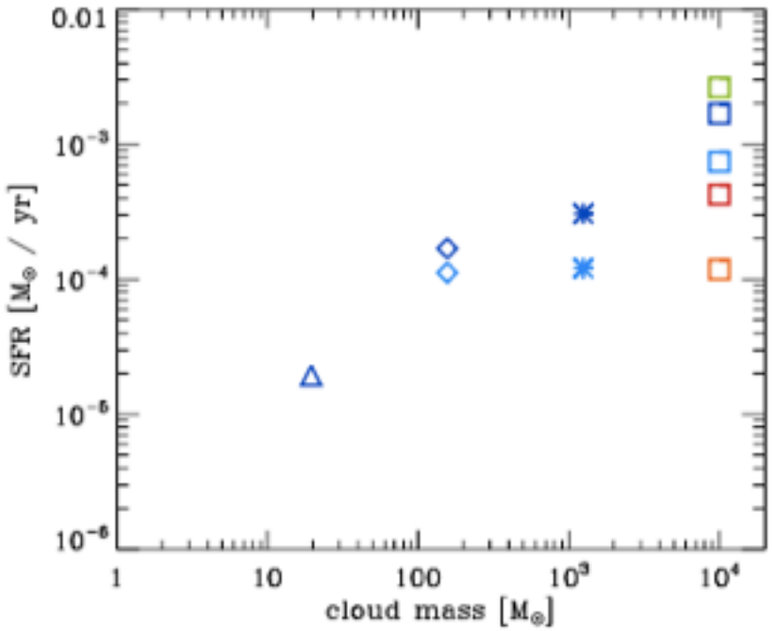
iv) 120 M_o pc^{-2} は閾値ではない。星間輻射を遮る境界

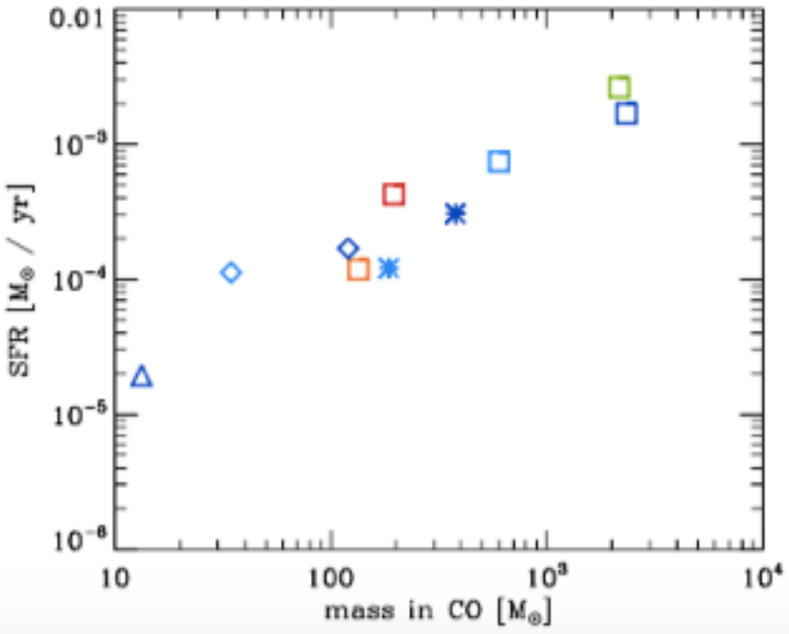
v) $n > 10^{4}$ cm^{-3} の体積と$N > 120$ M_o pc^{-2} の相関は低い

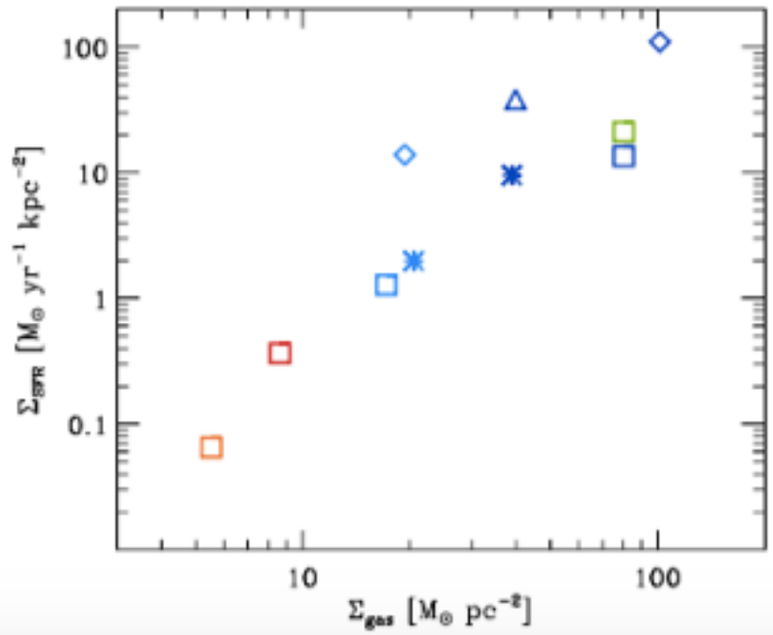
vi) 視線に沿ったAvと実効的なAvは違う

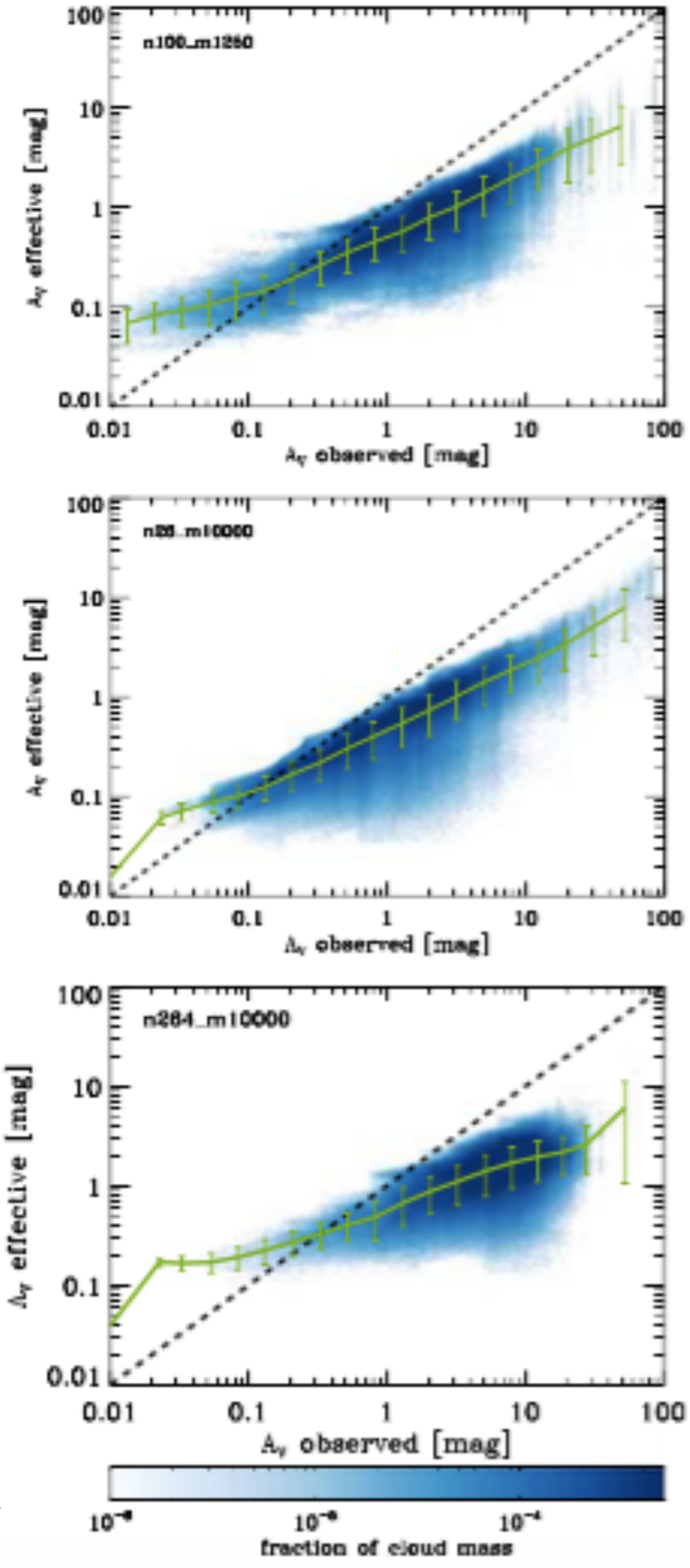
星形成率のパラメータ依存性











観測されるAv と実効的なAv