

Searching for young proto-planetary disks from ALMA archival data

Final presentation

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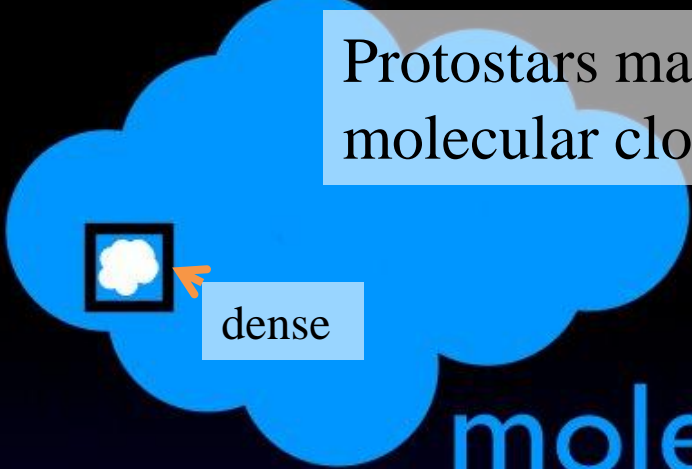
Date: 2015/08/28

Outline

- Introduction
- Works
Target
moment maps
position-velocity(p-v) diagrams
- Conclusions

Protostars mainly form from molecular clouds.

protostellar cloud



dense

molecular cloud



collapse

star with disk



proto-star with disk and jet



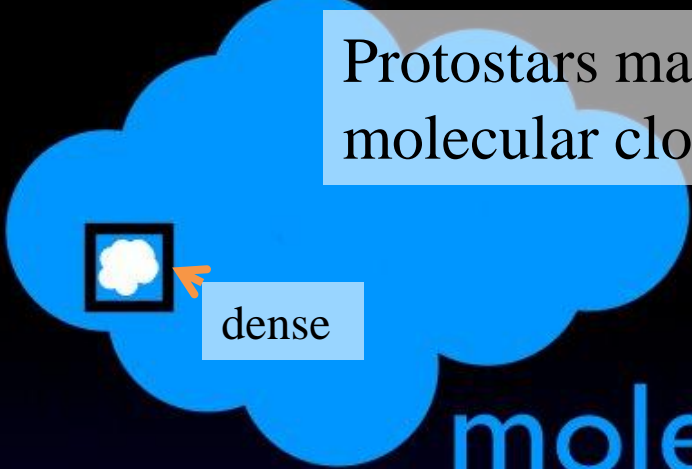
University of Washington
ASTRONOMY DEPARTMENT

star



Protostars mainly form from molecular clouds.

protostellar cloud



dense

molecular cloud



<https://youtu.be/UNPj7e6XJCQ>

star with disk



proto-star with disk and jet

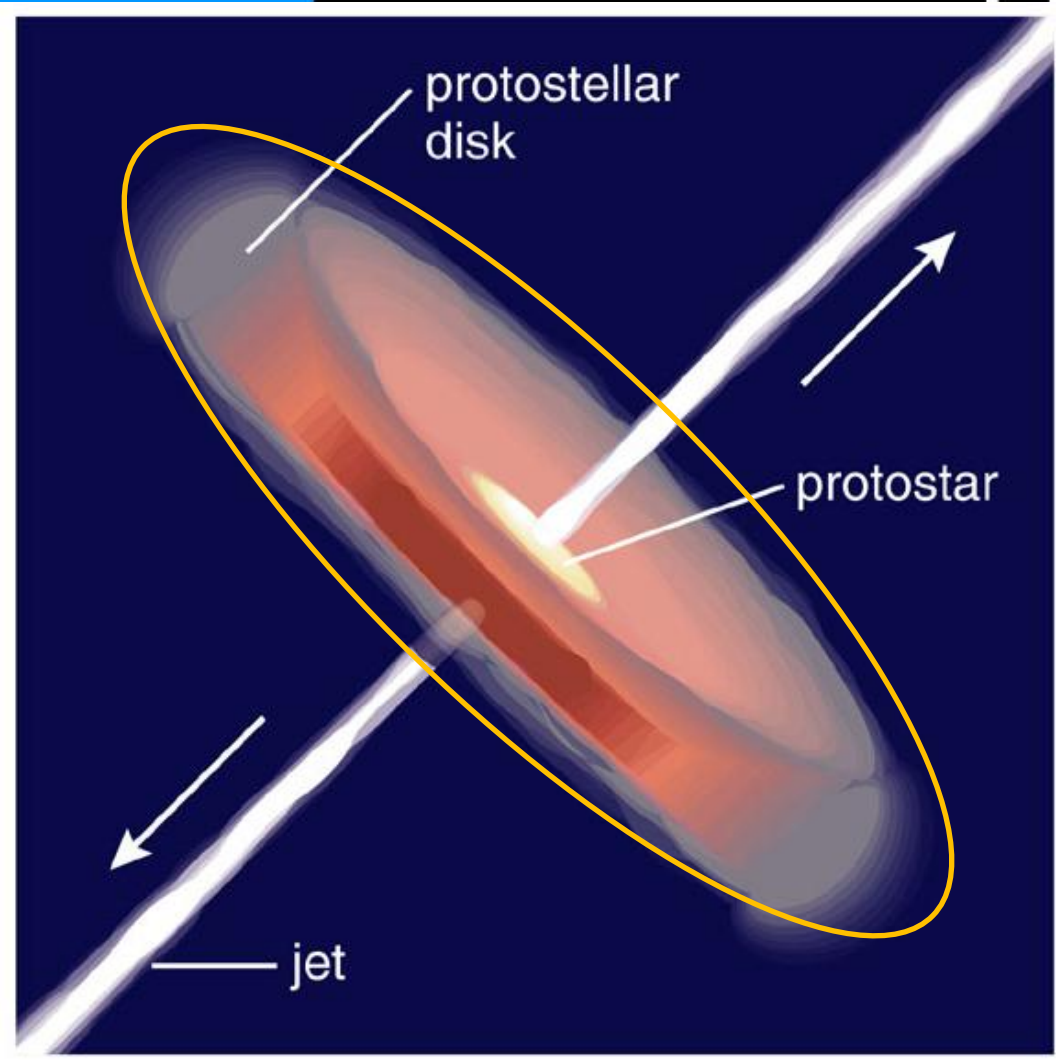


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star



protostellar cloud



Education, publishing as Addison Wesley.

Addison Wesley



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proto-stellar
disk and jet



Keplerian Disk (proto-star disk)

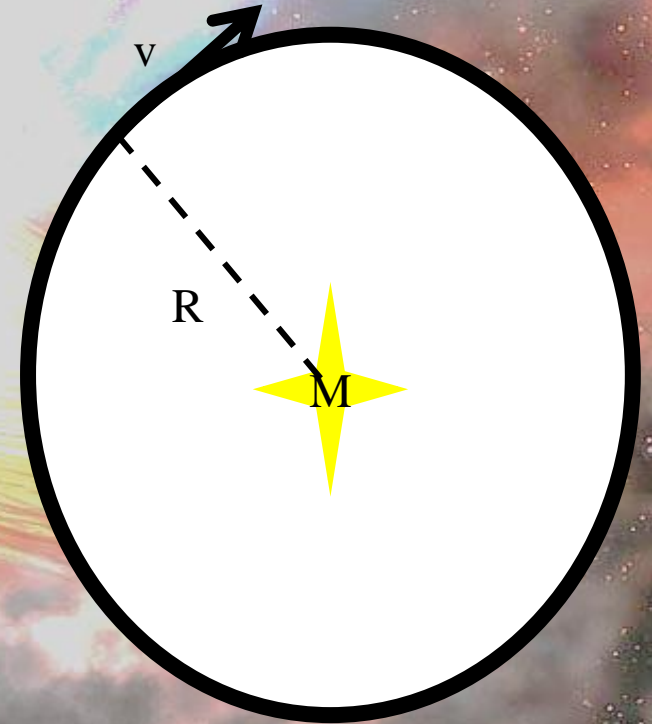
$$v = \sqrt{\frac{GM}{R}}$$

v: velocity of the molecular

R: from the central of the star

M: the mass of the object

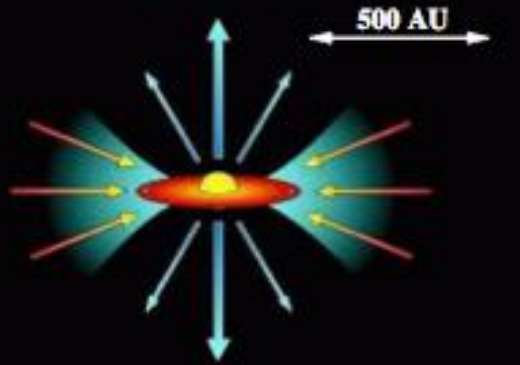
G: gravitational constant



Class 0

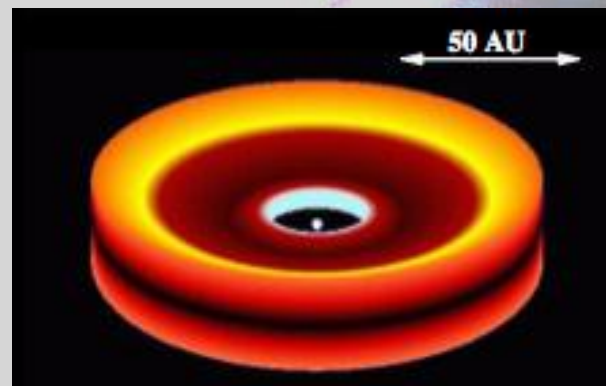


Class I



Pic: Meredith MacGregor

Class II



Class III





My Works

Method

- Data & information
ALMA SV data & archive data
Splatalogue
- Software
Common Astronomy Software Applications
(CASA)
- Knowledge
ADS

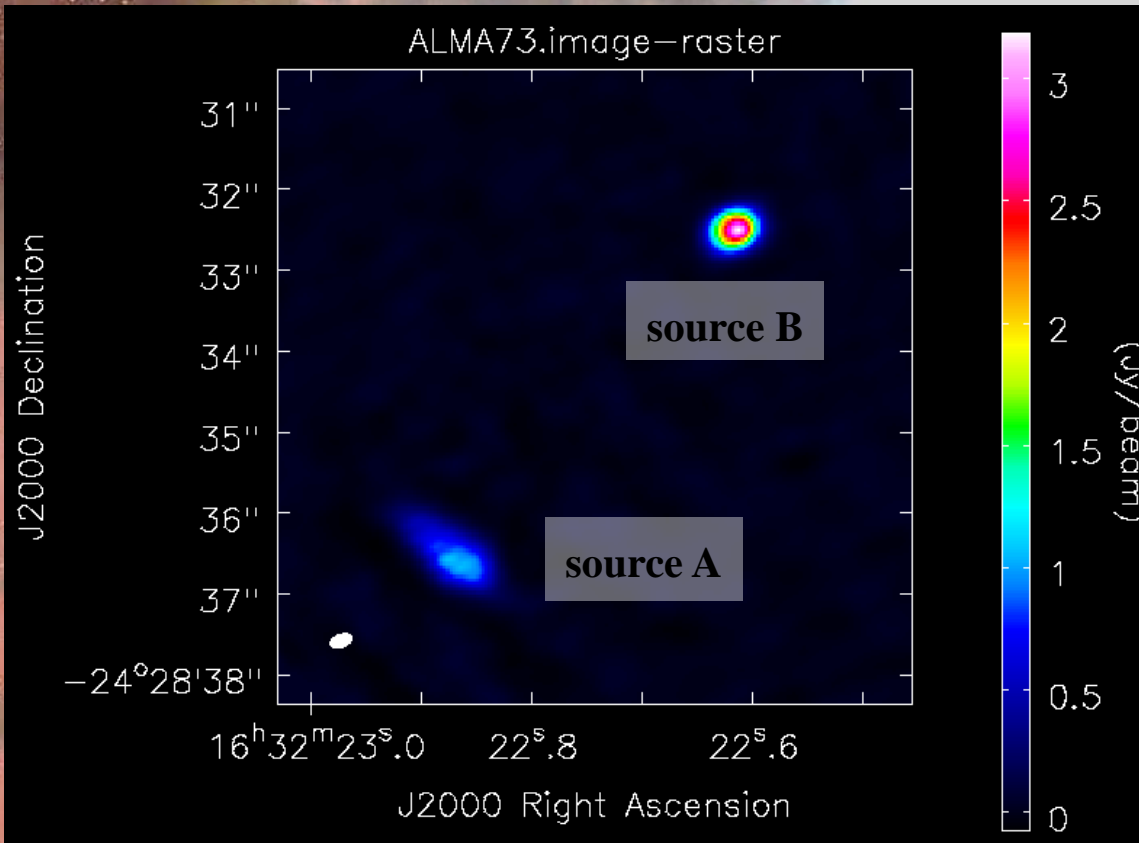
My Study

Protostar	Class	Line	Transition
IRAS16293 A&B	0	^{12}CO , H^{13}CN , $^{13}\text{CH}_3\text{OH}$	6-5, 8-7, 15-14
VLA1623	0	C^{18}O , DCO^+	2-1, 3-2
HD163296	II	^{13}CO , C^{18}O , ^{12}CO , ^{12}CO	2-1, 2-1, 2-1, 3-2
HL Tau	I to II	^{12}CO , HCO^+	1-0, 1-0

Species	Optically thick	Optically thin
^{12}CO	✓	
^{13}CO	Sometimes	✓
C^{18}O		✓

Star	Line	Transition	Rest Frequency (GHz)	Band	Transitional energy (K)
Information: Splatalogue					
IRAS16293A&B	^{12}CO	6-5	691.47308	9	82.9738
IRAS16293A&B	H^{13}CN	8-7	690.55207	9	116.0094
IRAS16293B	$^{13}\text{CH}_3\text{OH}$	15 (0,15)-14 (0,14)	703.88965	9	250.3083
VLA1623	C^{18}O	2-1	291.56036	6	5.2688
VLA1623	DCO^+	3-2	216.11258	6	10.3721
HD163296	^{12}CO	3-2	345.79599	7	16.5962
HD163296	^{13}CO	2-1	220.39868	6	5.2888
HD163296	C^{18}O	2-1	219.56036	6	5.2688
HD163296	^{12}CO	2-1	230.53800	6	5.5321
HL Tau	^{12}CO	1-0	115.27120	3	0
HL Tau	HCO^+	1-0	89.18853	3	0

IRAS16293-2422A&B



IRAS 16293–2422 is a well studied low-mass very young star.

A&A 2013 Luis A. Zapata et al

Constellation	Ophiuchus
Right ascension	16 ^h 32 ^m 22.736 ^s
Declination	-24° 28' 32.5''
Beam size	0''.29 X 0''.17
Band	9

Continuum image

Moment maps of IRAS16293-2422A

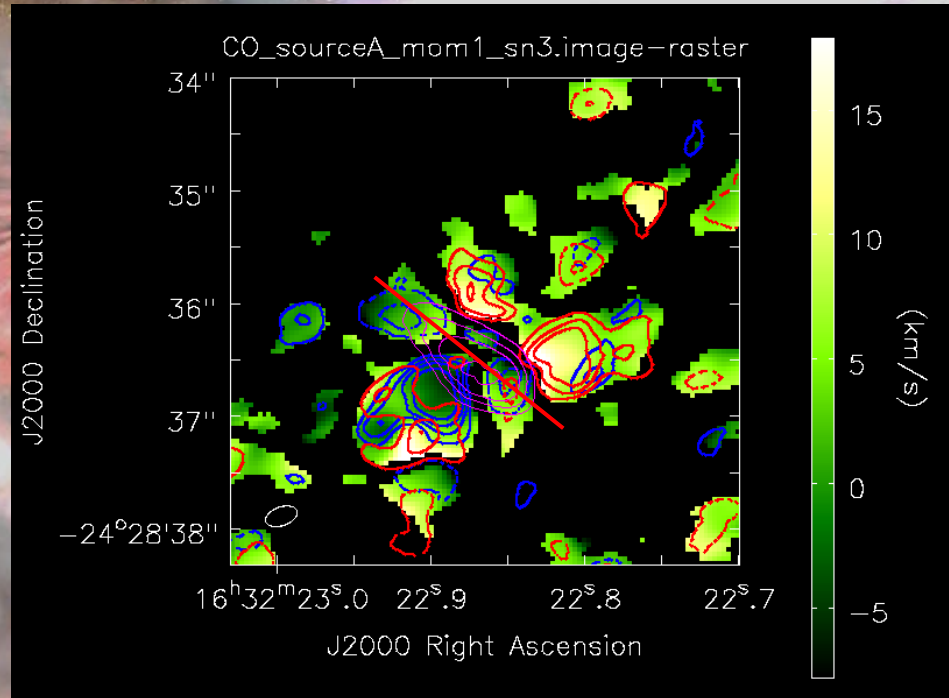


Figure shows Intensity (contours) and velocity (color-scale) integrated map of ^{12}CO .

Contours are in steps of $-3, 3, 5, 7\sigma$ with $\sigma=0.1\text{Jy/beam}$.

blue contours: blue-shift; red contours: red-shift; magenta contour: IRAS16293-2422A

Moment maps of IRAS16293-2422A

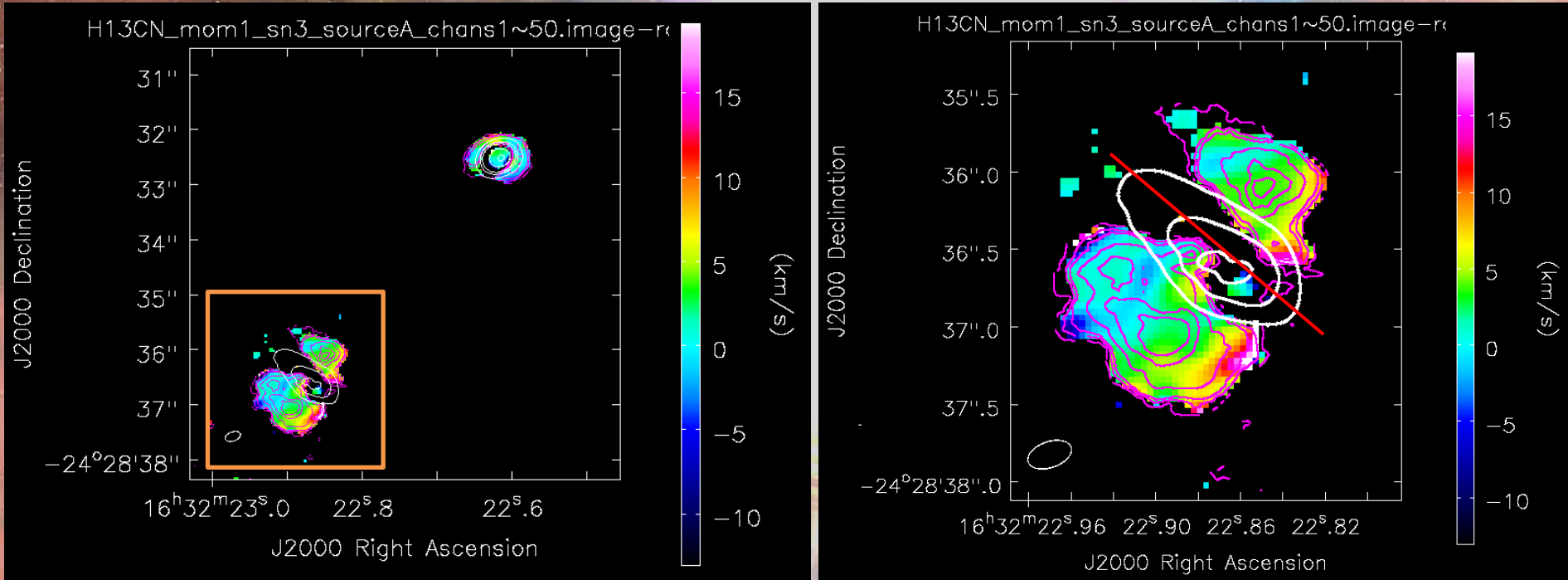
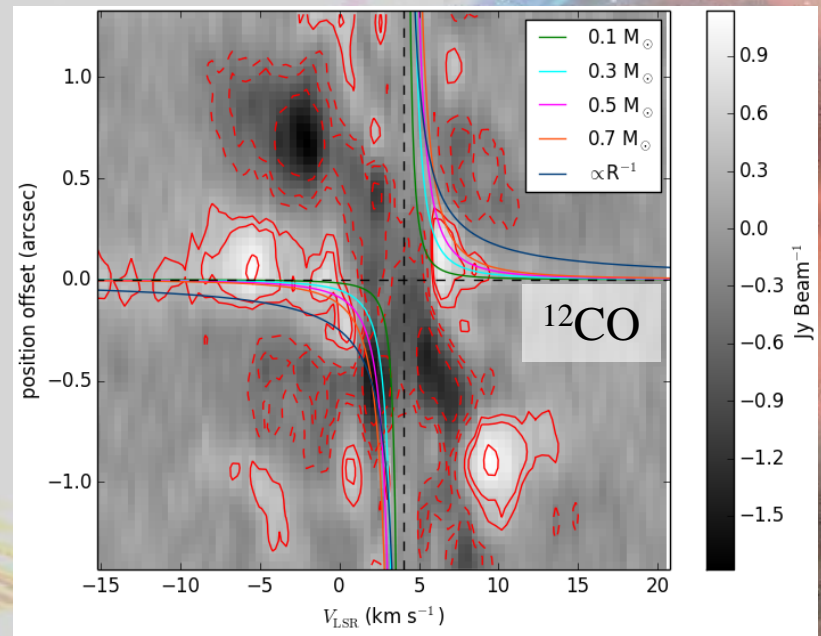
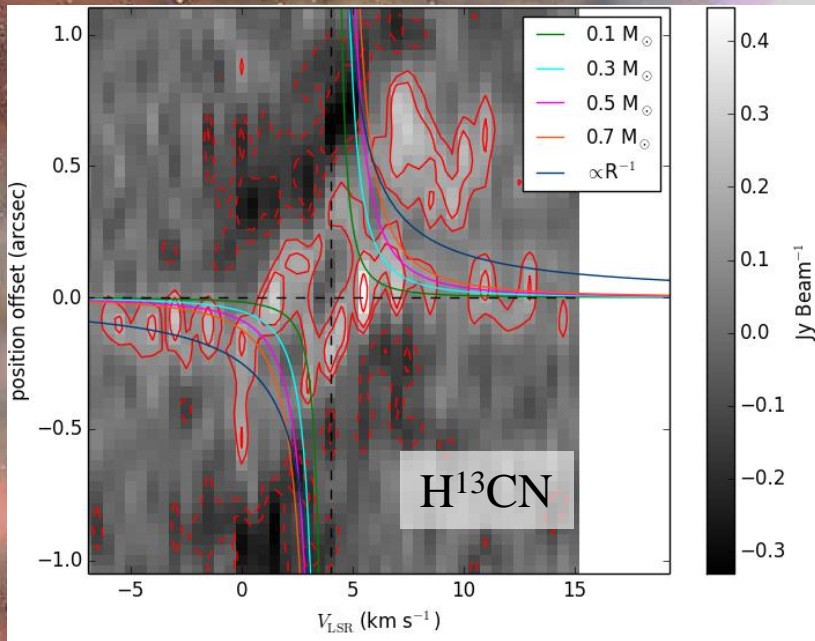


Figure shows Intensity (contours) and velocity (color-scale) integrated map of H¹³CN.
Contours are in steps of 3, 5, 7, 10, 20, 30 σ with $\sigma=20\text{mJy/beam}$.
white contour: IRAS16293-2422A

P-V diagrams of IRAS16293-2422A

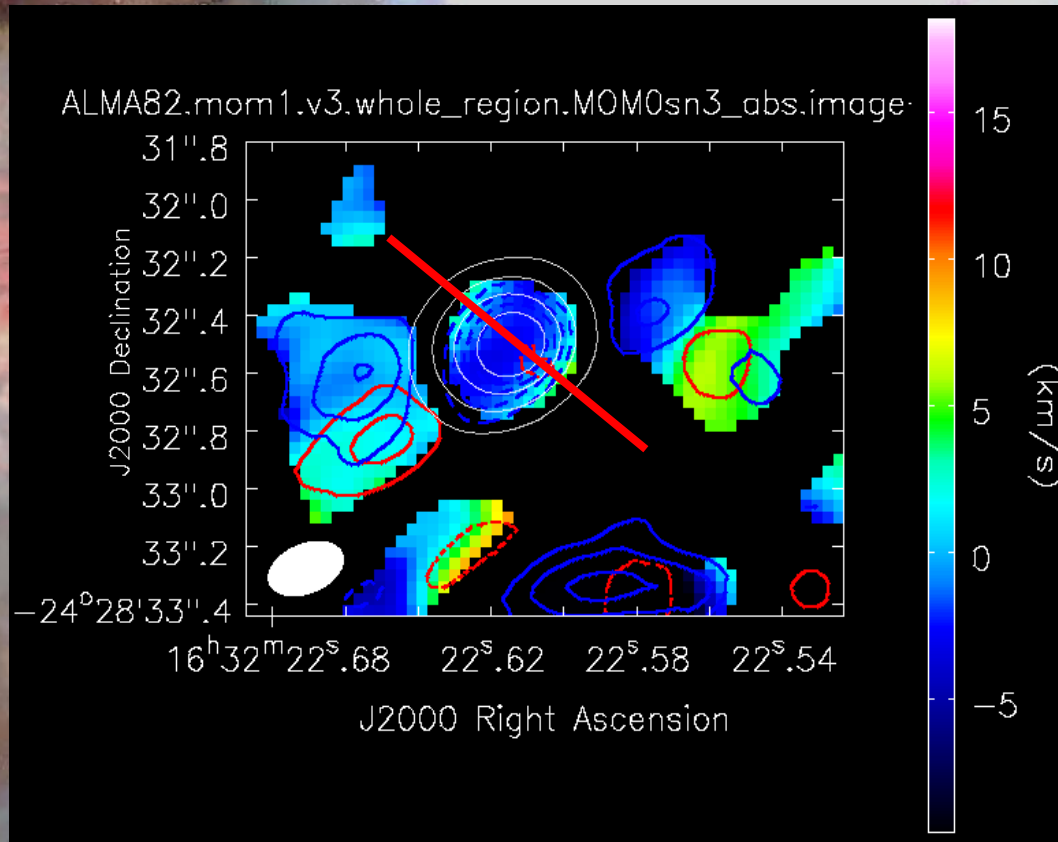


Left figure: H¹³CN right figure: ¹²CO

Contours are in steps of -20, -10, -5, -3, 3, 5, 10, 20σ σ = 20 mJy/beam for H¹³CN, σ = 0.1 Jy/beam for ¹²CO.

curves: kepler's third law, different colors represent different masses of the proto-star. (except blue line: infall)

Moment maps of IRAS16293-2422B



The figure shows intensity (contours) and velocity (color-scale) integrated map of $^{12}\text{CO}(J=6-5)$. Contours are in steps of $-3, 3, 5, 7\sigma$ with $\sigma = 1.9\text{Jy/beam}$
blue contours: blue-shift; red contours: red-shift; white contour: IRAS16293-2422B

Moment maps of IRAS16293-2422B

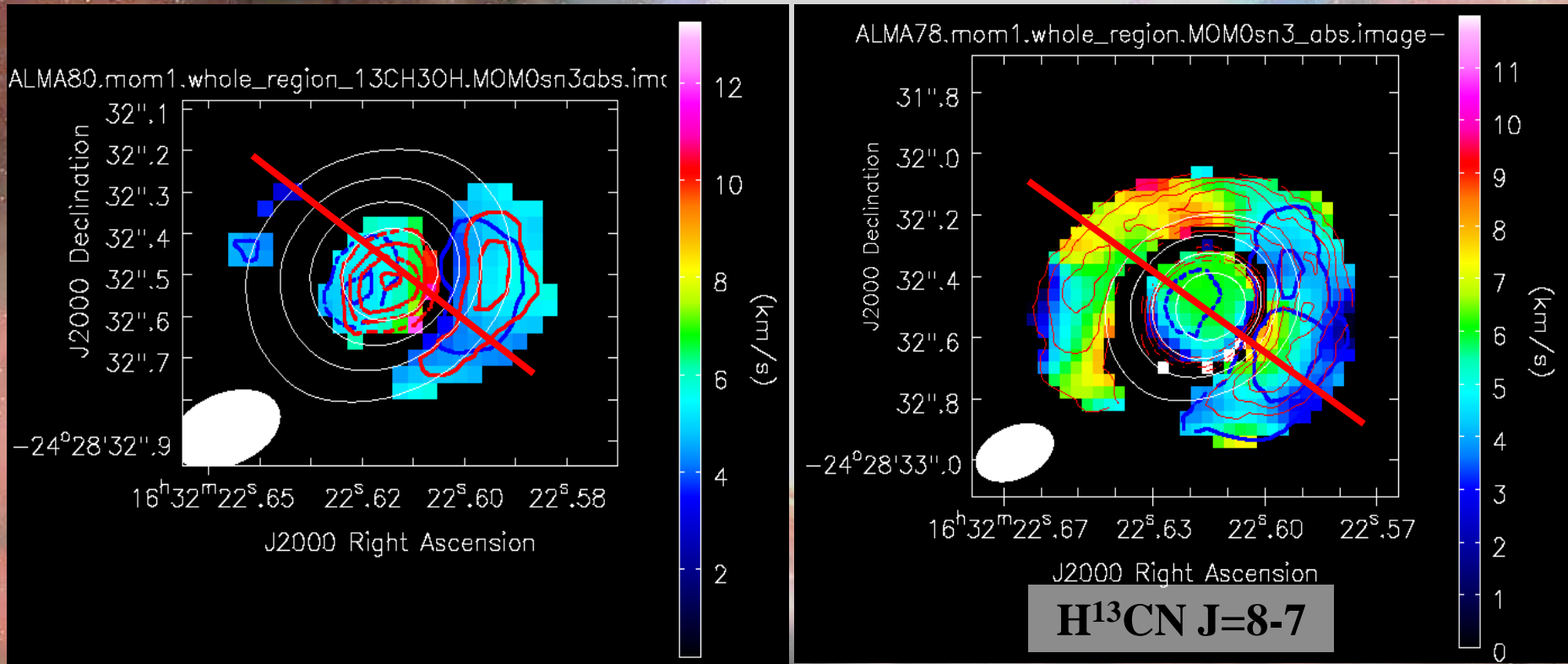
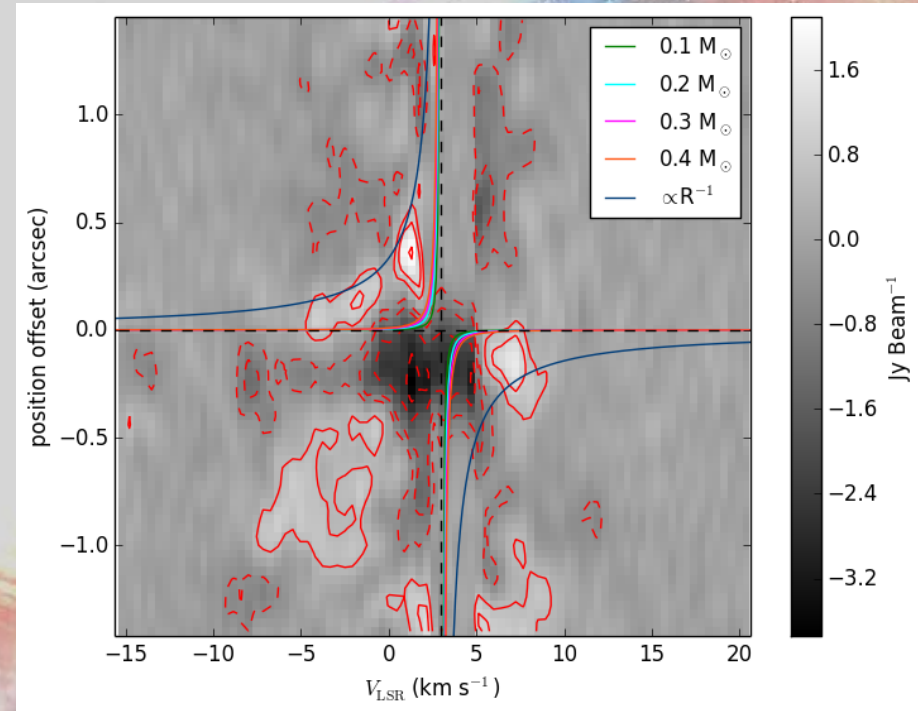
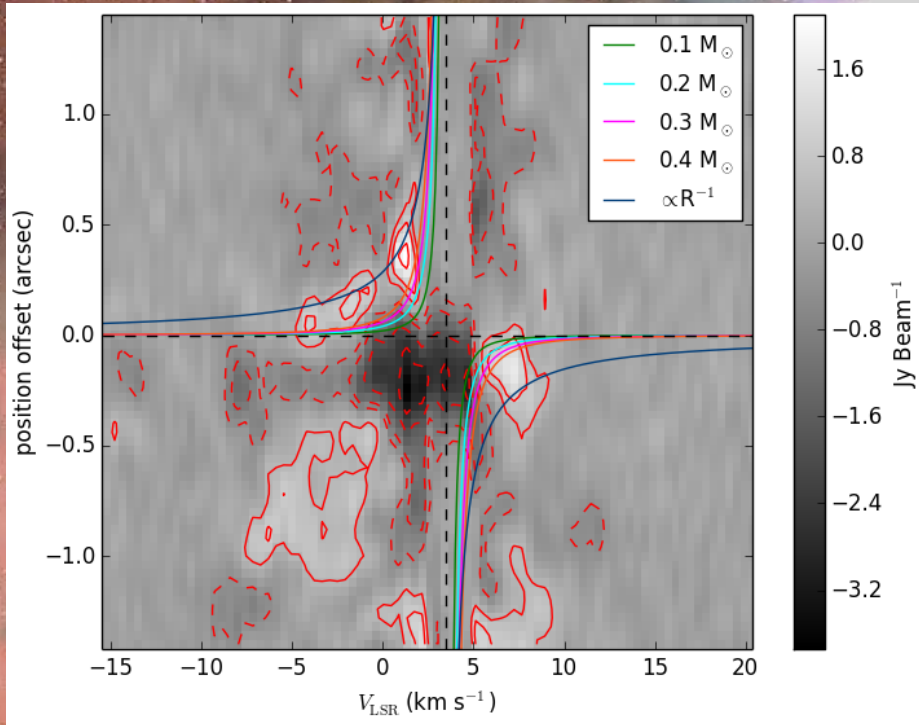


Fig. 1b&1c Intensity (contours) and velocity (color-scale) integrated maps of $^{13}\text{CH}_3\text{OH}$ and H^{13}CN . Contours are in steps of $-3, 3, 5, 7\sigma$ with $\sigma = 0.16\text{Jy/beam}$
blue contours: blue-shift red contours: red-shift white contour: IRAS16293-2422B

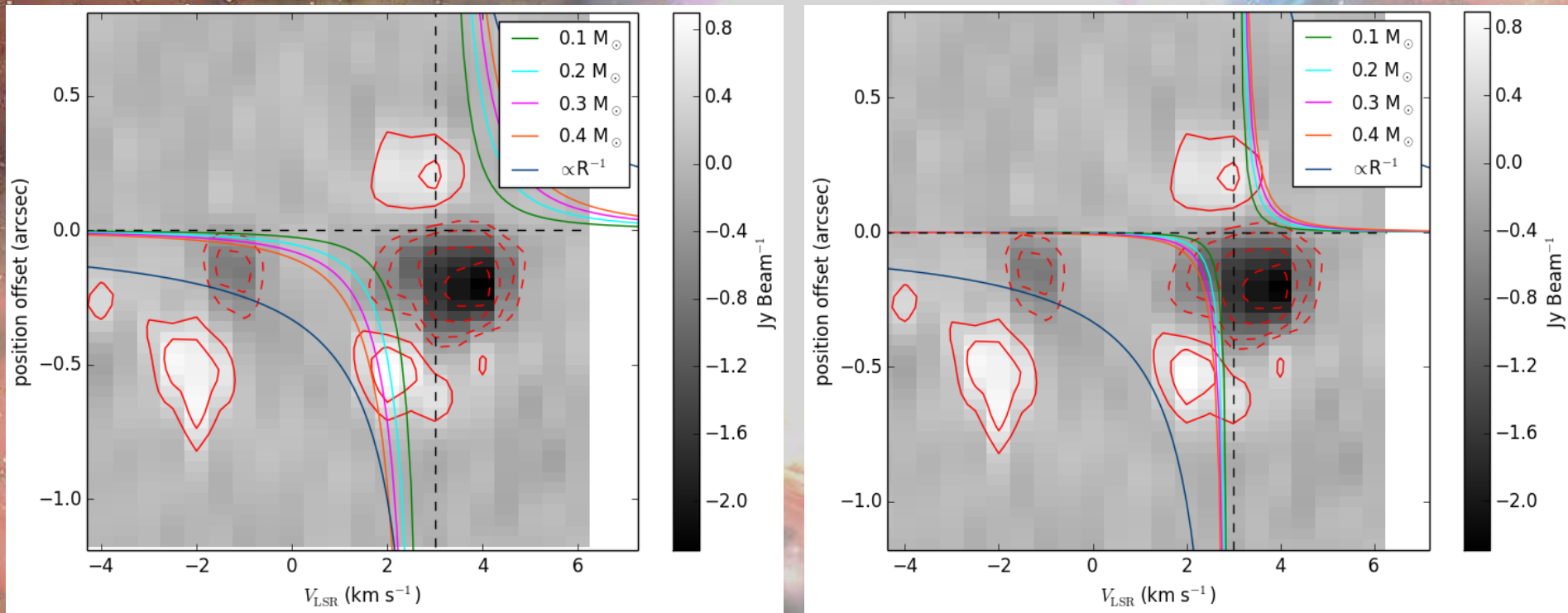
P-V diagrams (line: ^{12}CO)



Left figure: without inclination angle, right figure: with inclination angle
*inclination angle = 73° (for my assumption)

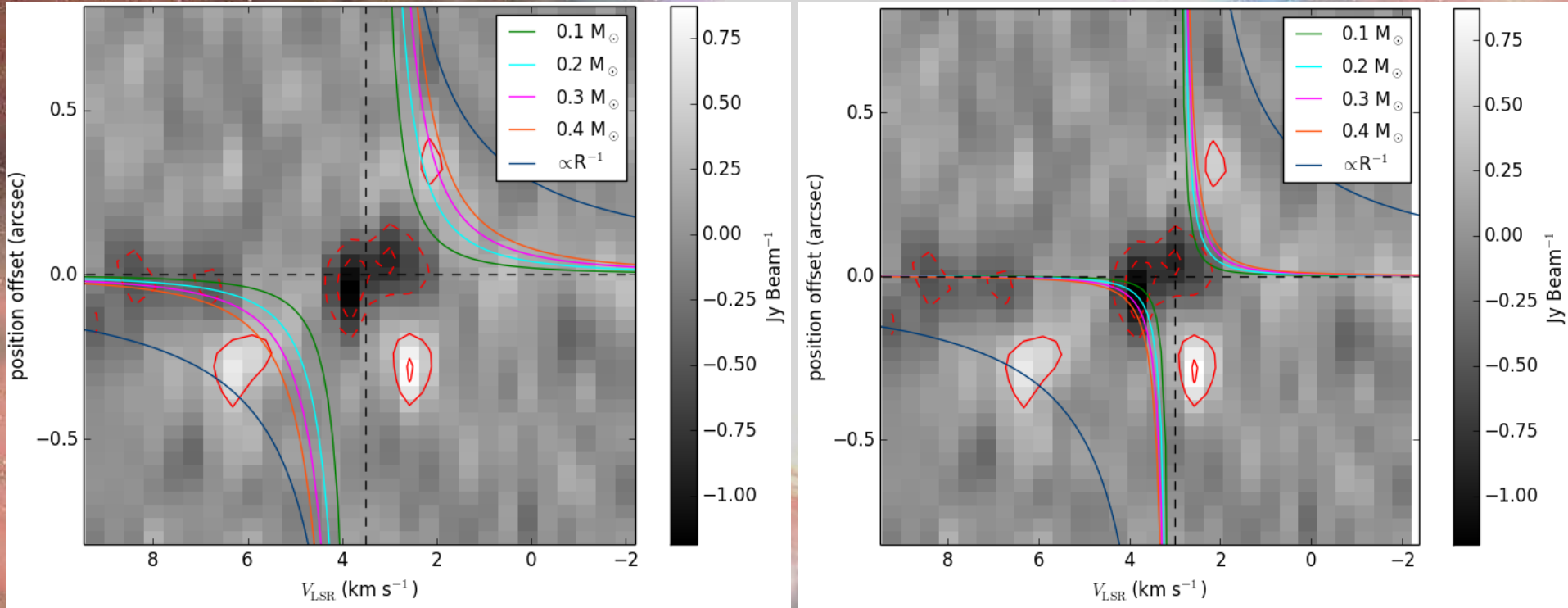
Contours are in steps of -20, -10, -5, -3, 3, 5, 10, 20σ $\sigma = 0.1$ Jy/beam for ^{12}CO .
curves: the kepler's third law of, different colors represent different masses of the proto-star.(except blue line: infall)

P-V diagrams (line: H^{13}CN)



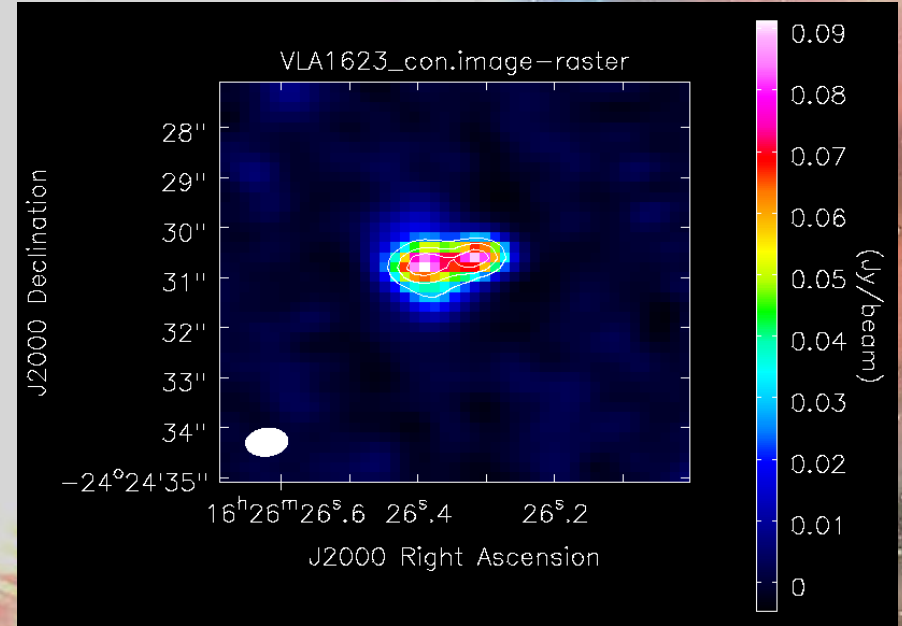
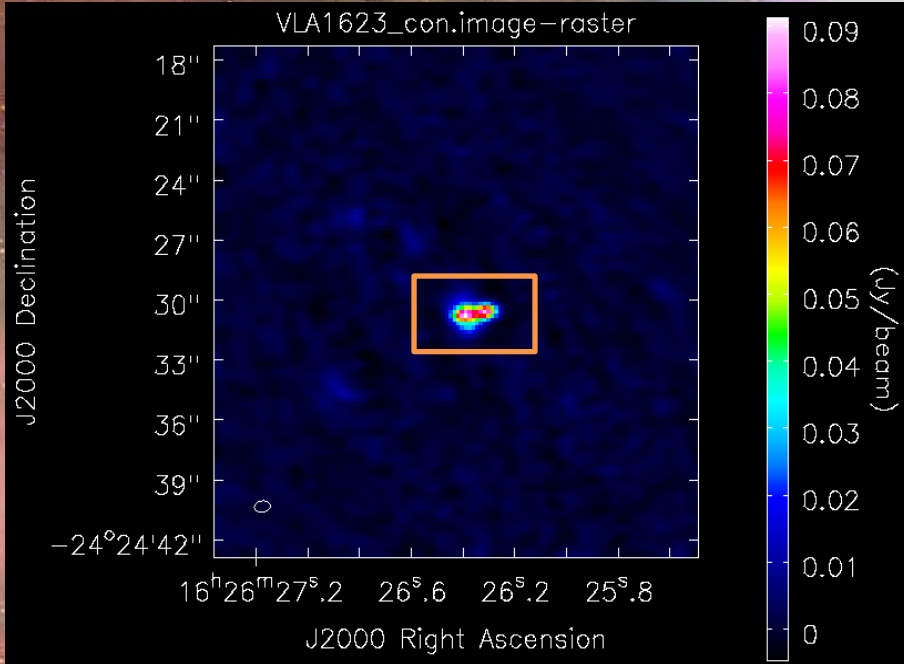
Left figure: without inclination angle, right figure: with inclination angle
Contours are in steps of -20, -10, -5, -3, 3, 5 σ $\sigma = 60 \text{ mJy/beam}$ for H^{13}CN .
curves: the kepler's third law of, different colors represent different masses of the proto-star. (except blue line: infall)

P-V diagrams (line: $^{13}\text{CH}_3\text{OH}$)



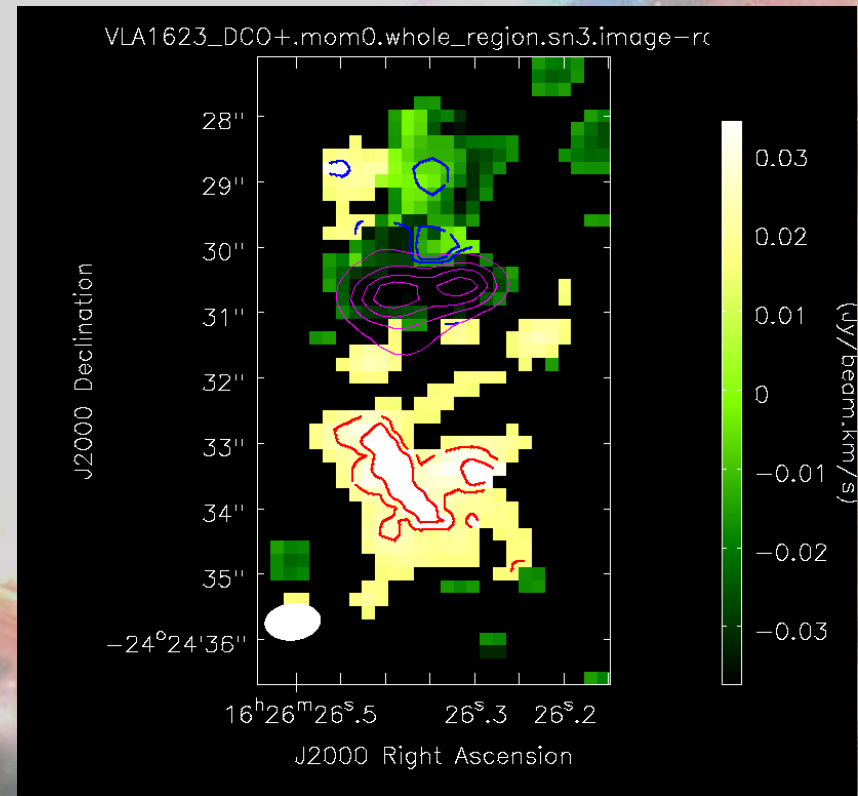
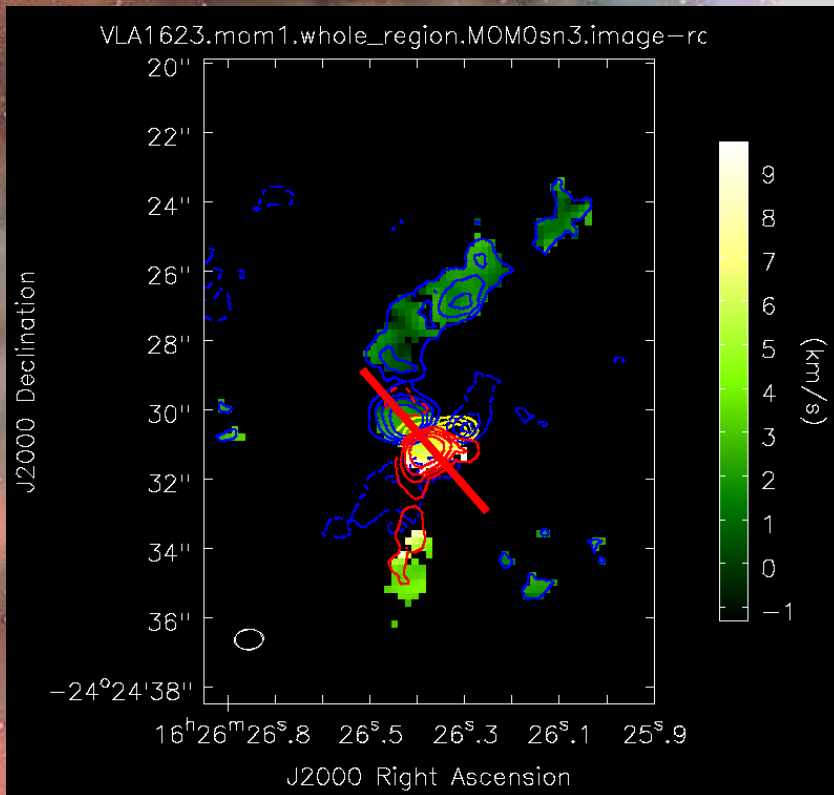
Left figure: without inclination angle, right figure: with inclination angle
Contours are in steps of $-5, -3, 3, 5\sigma$ $\sigma = 80\text{mJy/beam}$ for $^{13}\text{CH}_3\text{OH}$.
curves: the kepler's third law of, different colors represent different masses of the proto-star.(except blue line: infall)

VLA1623



Constellation	Ophiuchus
Right ascension	16 ^h 26 ^m 26.419 ^s
Declination	-24° 24' 29.988"
Beam size	0".85 X 0".56
Band	6

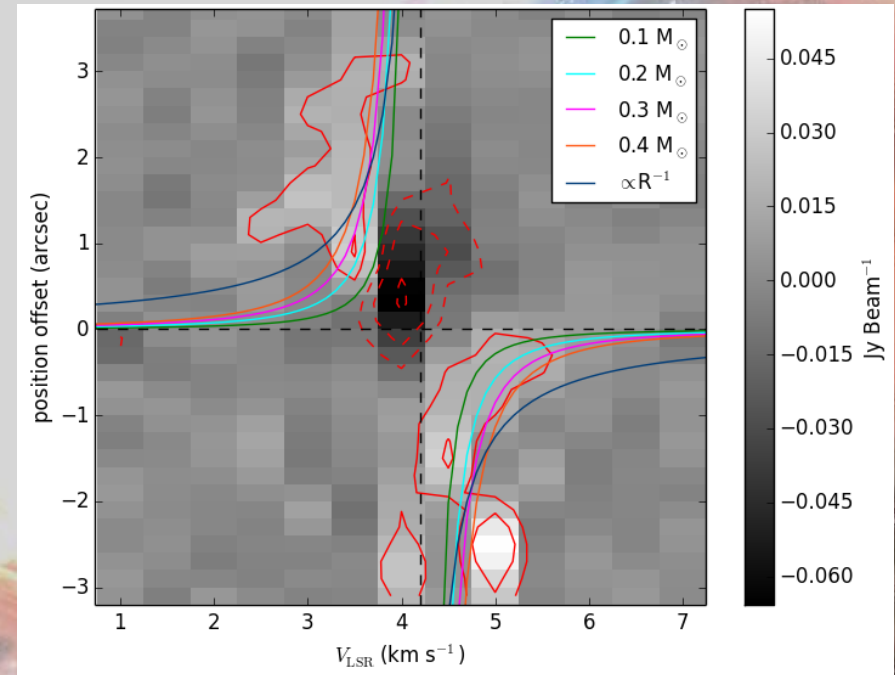
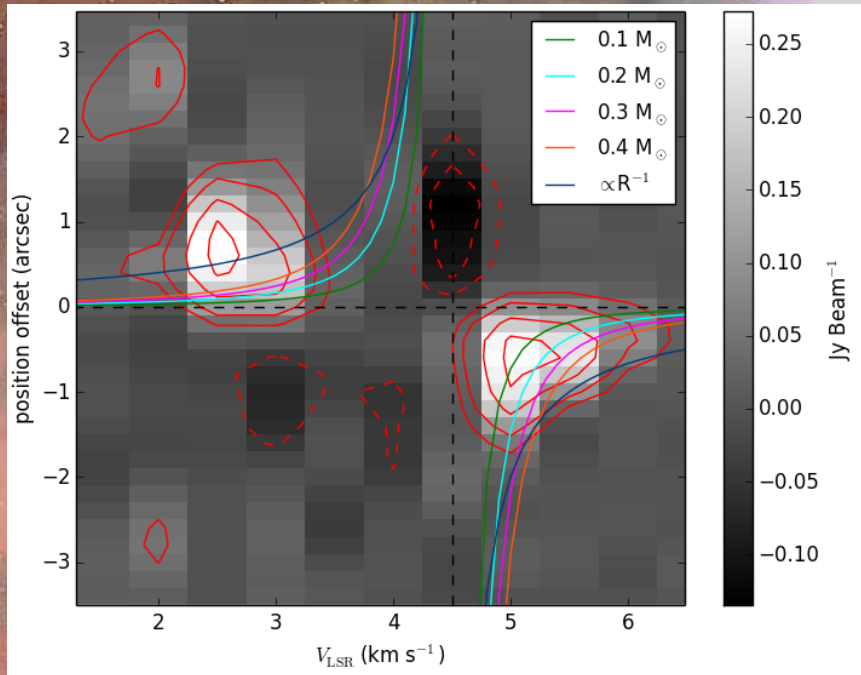
Moment maps



Figures show left: Intensity (contours) and velocity (color-scale) integrated map of C¹⁸O, right: Intensity integrated map of DCO⁺. Contours are in steps of -3, 3, 5, 7, 10, 20 σ with $\sigma=10\text{mJy/beam}$ for C¹⁸O $\sigma=5\text{mJy/beam}$ for DCO⁺.

blue contours: blue-shift; red contours: red-shift; yellow/ magenta contour: VLA1623

P-V diagram of VLA1623

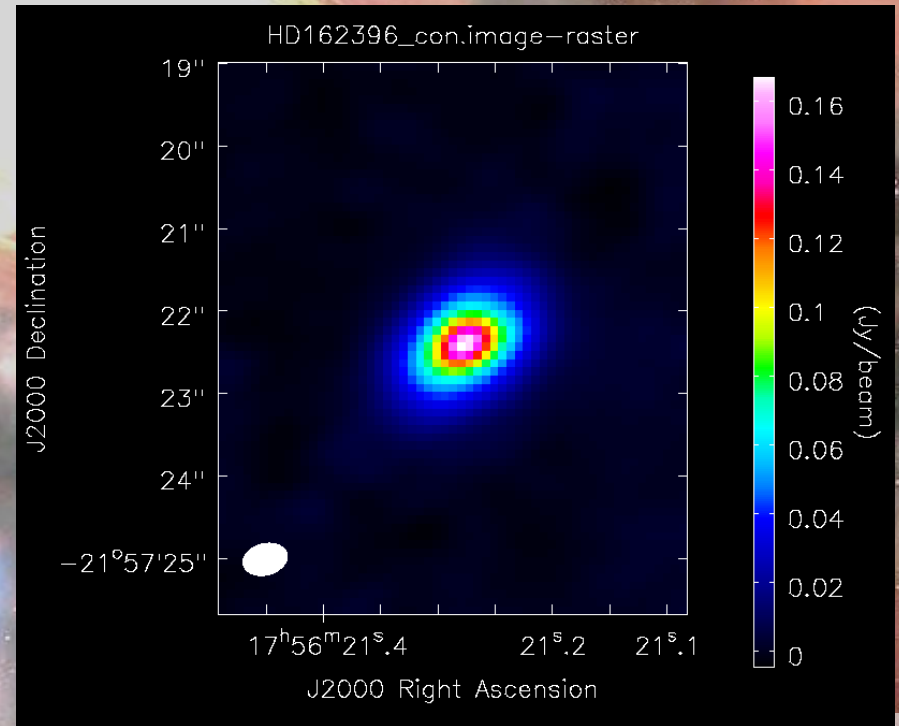
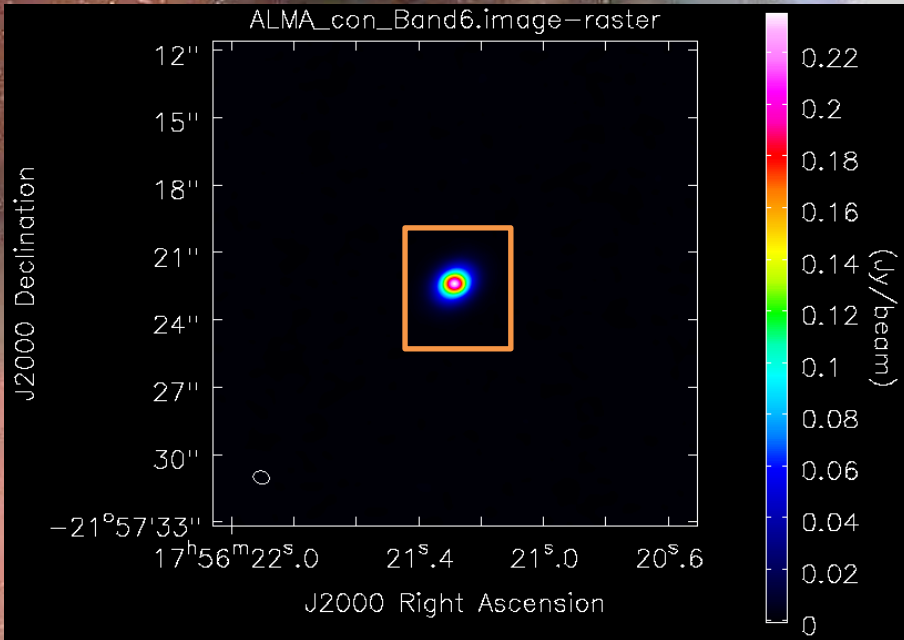


Left figure: C¹⁸O, right figure: DCO⁺

Contours are in steps of -20, -10, -5, -3, 3, 5, 10, 20, 30 σ $\sigma = 8\text{mJy/beam}$ for C¹⁸O, $\sigma = 3\text{mJy/beam}$ for DCO⁺.

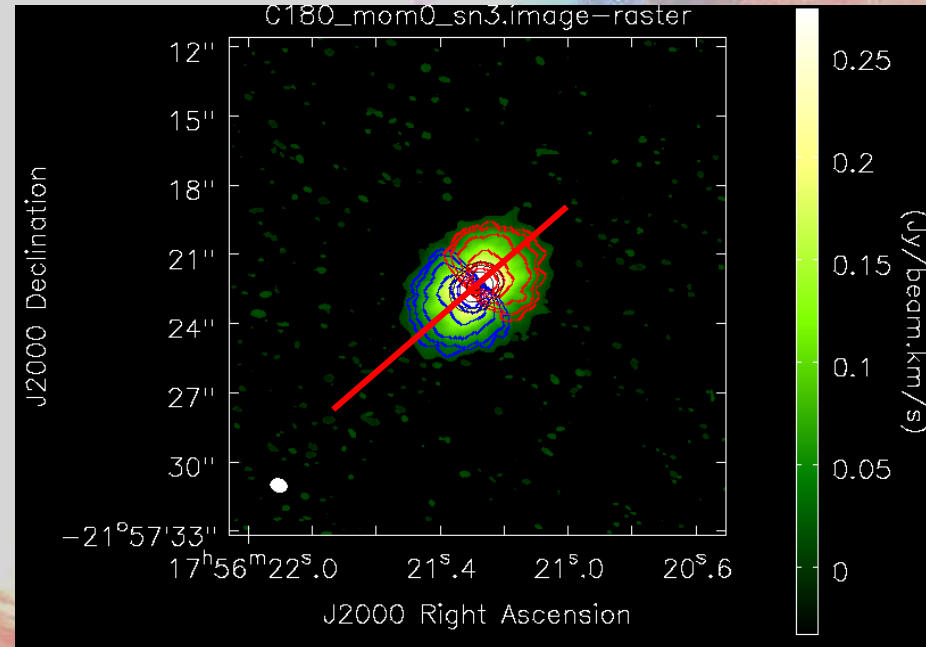
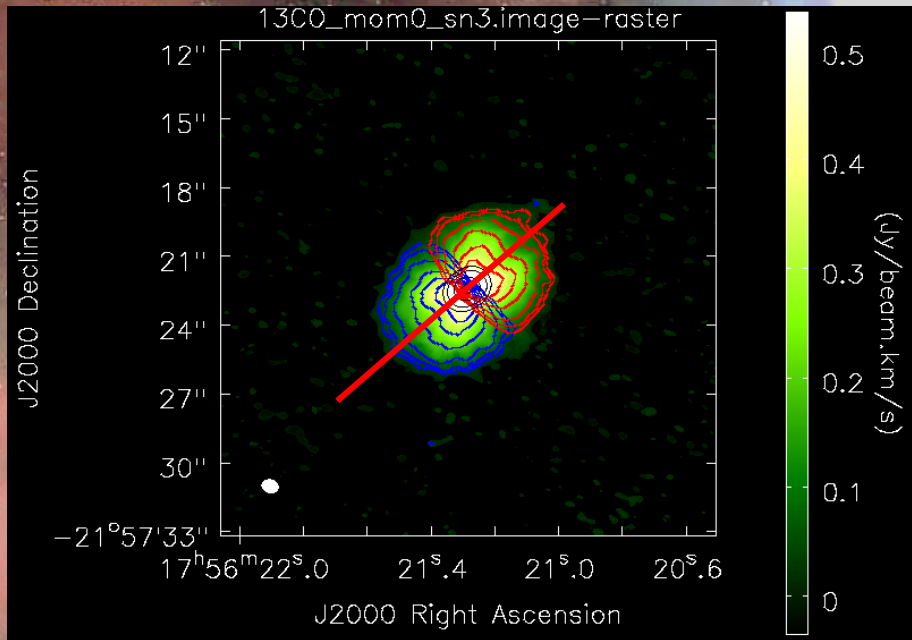
curves: the kepler's third law of, different colors represent different masses of the proto-star.(except blue line: infall)

HD163296



Constellation	Sagittarius
Right ascension	17 ^h 56 ^m 21.280 ^s
Declination	-21° 57' 32.434"
Beam size	0".55 X 0".38
Band	6

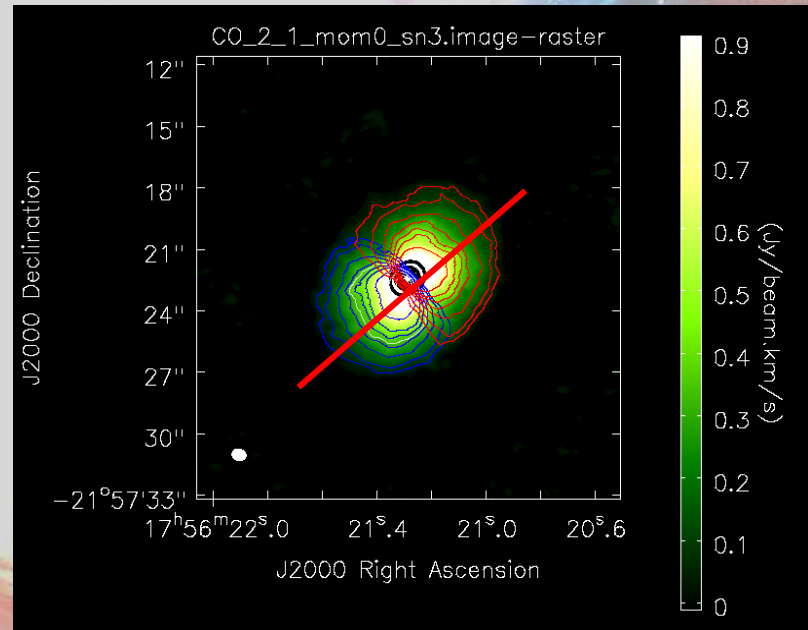
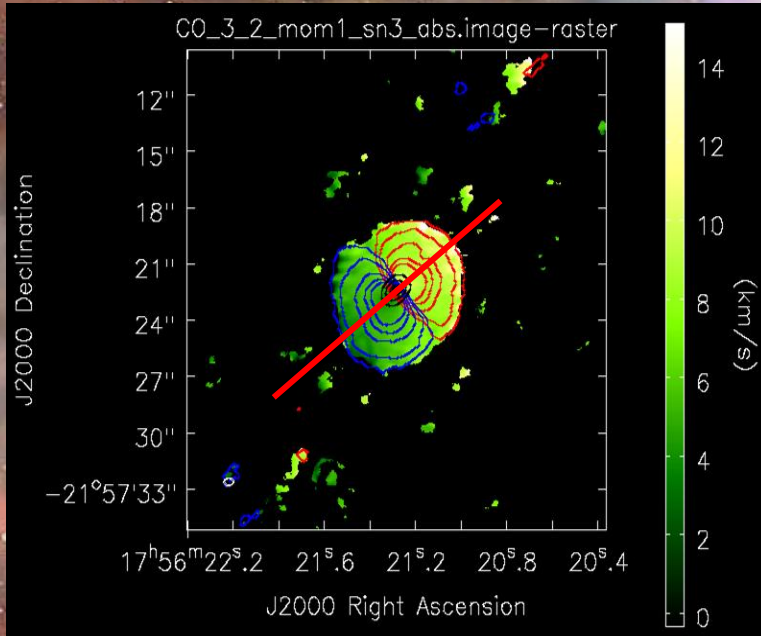
HD163296 moment maps



Figures show (left & right) Intensity of ^{13}CO and C^{18}O . Contours are in steps of 3, 5, 10, 20, 30, 40 σ with $\sigma = 10\text{mJy/beam}$ and $\sigma = 7\text{mJy/beam}$ for C^{18}O .

blue contours: blue-shift red contours: red-shift
black contour: the continuum emission red line :p-v cut

Moment maps

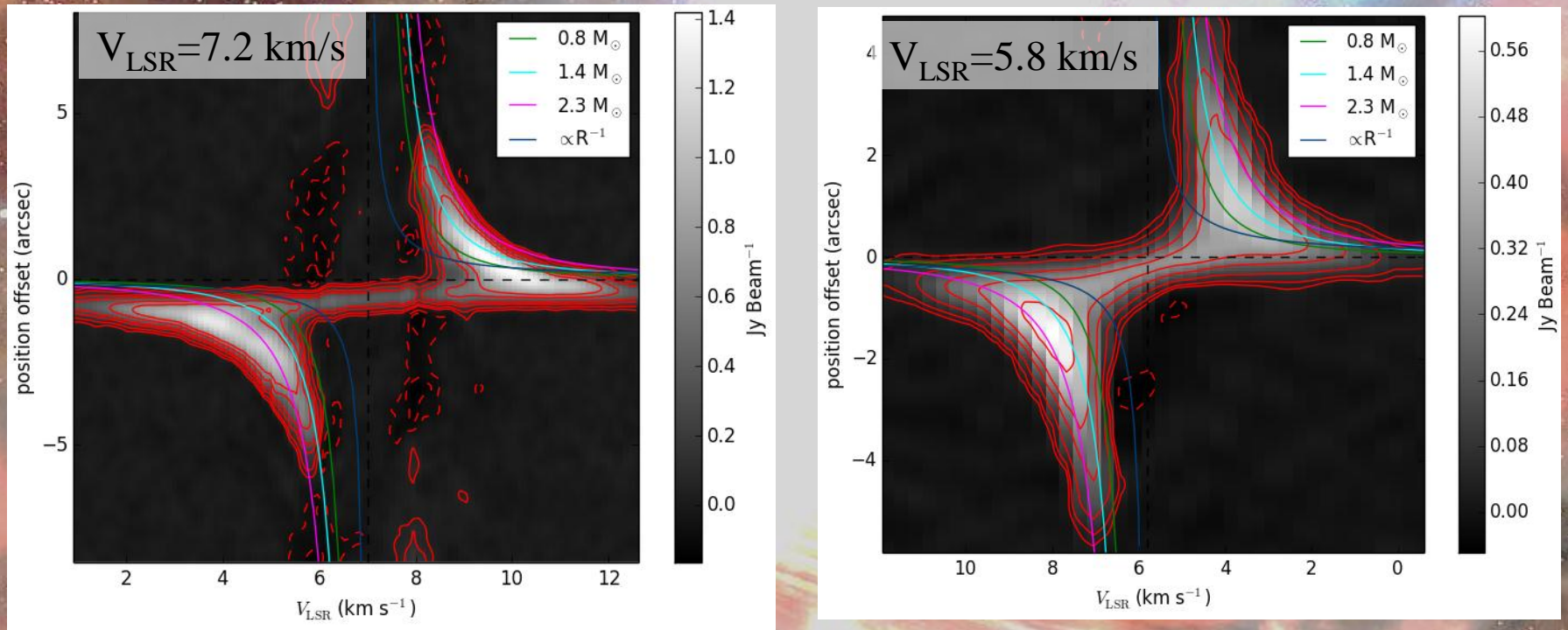


The figure(left) shows, intensity (contours) and velocity (color-scale) integrated map of $^{12}\text{CO}(\text{J}=3-2, \text{Band}7)$. Contours are in steps of 5, 10, 20, 30, 40 σ with $\sigma = 30\text{mJy/beam}$.

Right-hand side shows the intensity map of $^{12}\text{CO}(\text{J}=2-1, \text{Band}6)$. Contours are in steps of 5, 10, 20, 30, 40, 50, 70 σ with $\sigma = 10\text{mJy/beam}$.

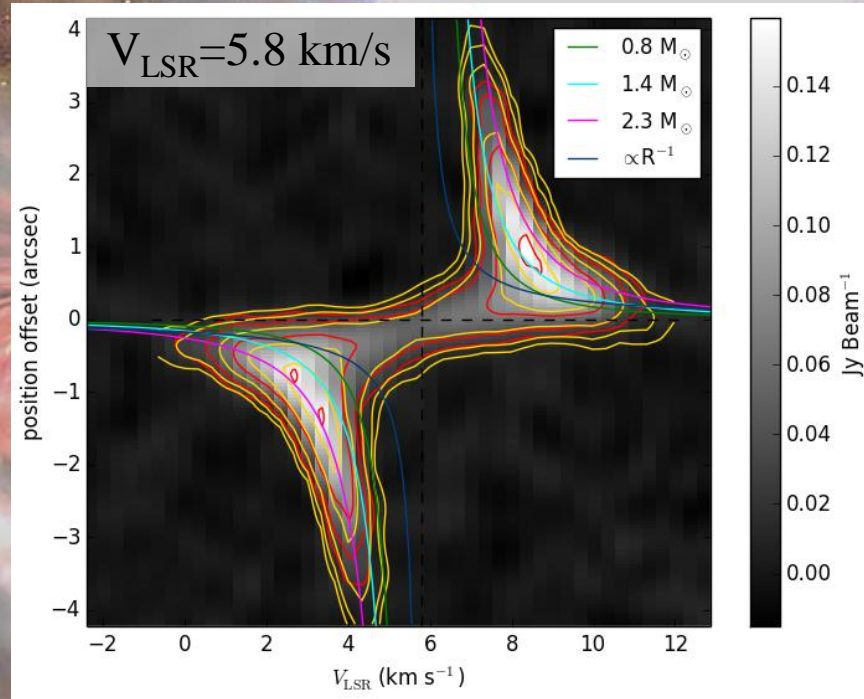
blue contours: blue-shift; red contours: red-shift red line: p-v cut

P-V diagrams of HD163296



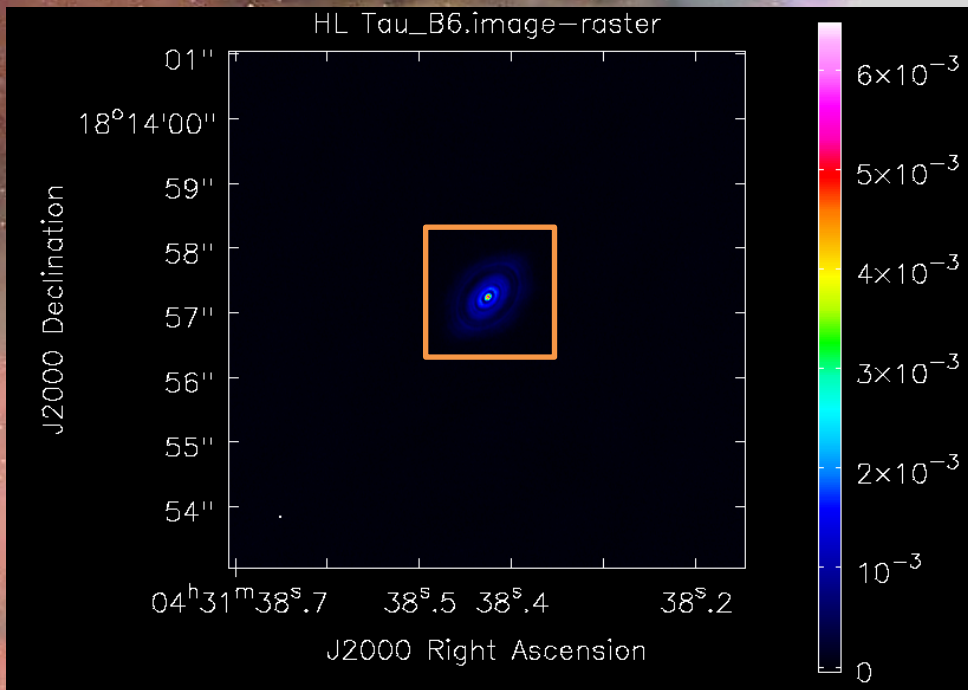
The figures show, left: $^{12}\text{CO}(J=3-2)$, right: $^{12}\text{CO}(J=2-1)$
Contours are in steps of 5, 10, 20, 30, 50, 70 σ with $\sigma = 10 \text{ mJy/beam}$ for $^{12}\text{CO}(J=3-2)$, 3, 5, 10, 20, 30 σ with $\sigma = 10 \text{ mJy/beam}$ for $^{12}\text{CO}(J=2-1)$,
curves: kepler's third law, different colors represent different masses of the proto-star.(except blue line: infall)

P-V diagrams of HD163296

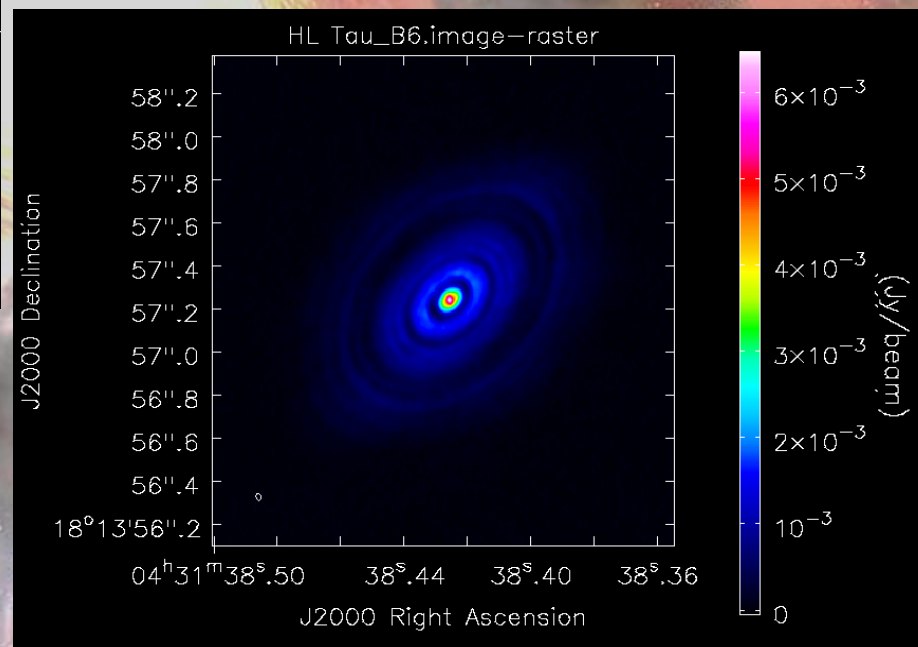


The figure shows, yellow contours: ¹³CO, red contours: C¹⁸O
Contours are in steps of 3, 5, 10, 20, 30 σ with $\sigma = 10$ mJy/beam
curves: Kepler's third law, different colors represent different masses of the proto-star. (except blue line: infall)

HL Tau



* continuum image band6



Constellation	Taurus
Right ascension	16 ^h 32 ^m 22.736 ^s
Declination	-24° 28' 32.5"
Beam size	0".08 X 0".06
Band	3

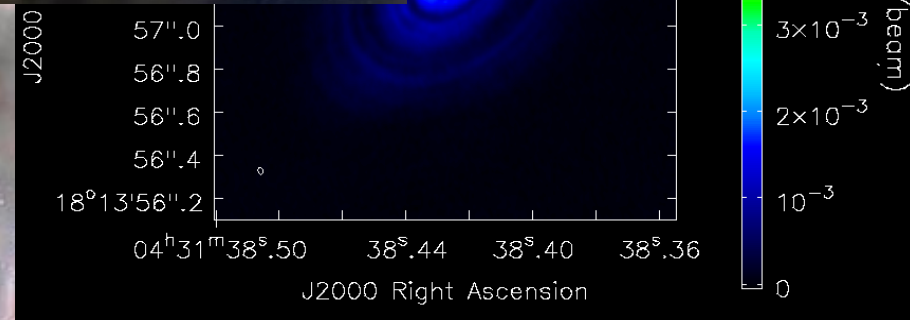
HL Tau

youtube

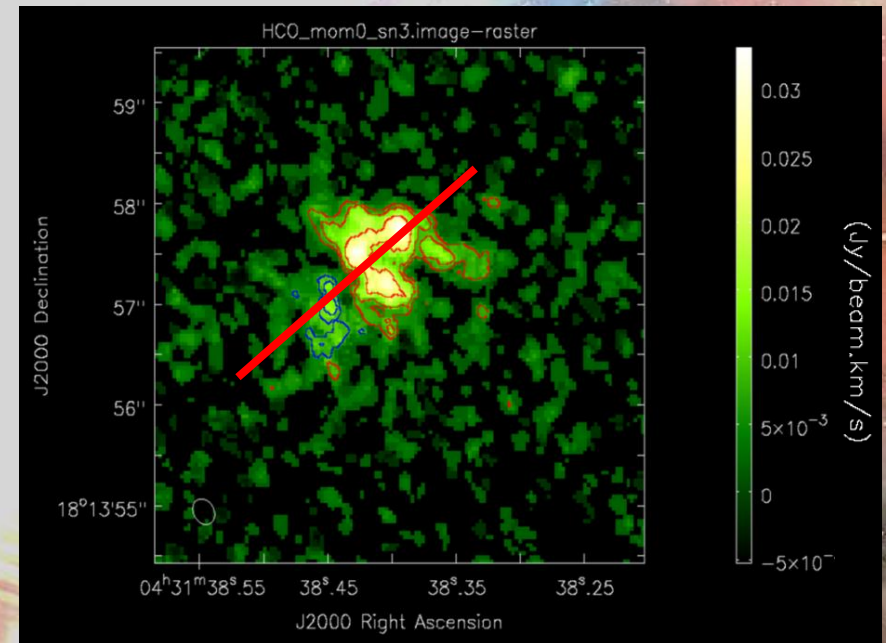
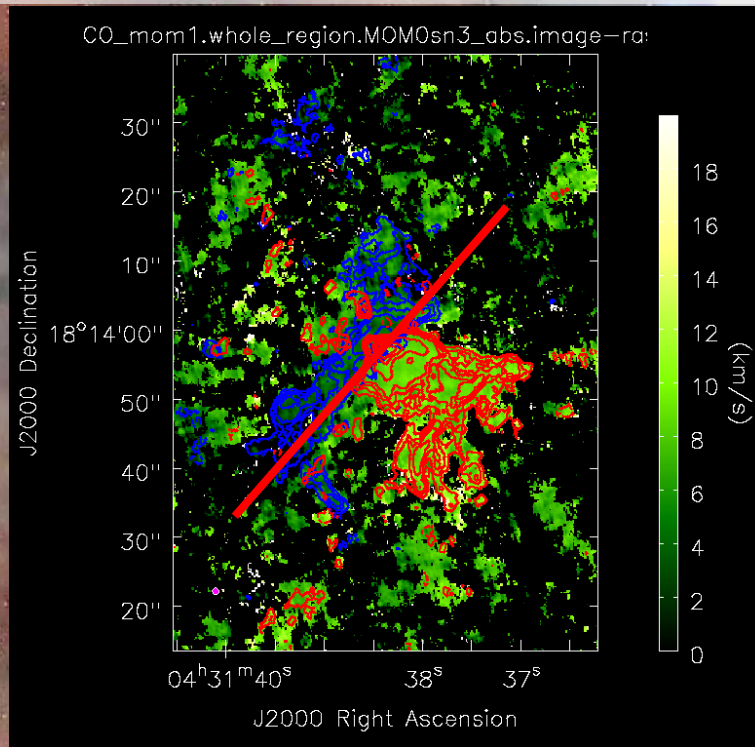
band6

6.image-raster

Constellation	Taurus
Right ascension	16 ^h 32 ^m 22.736 ^s
Declination	-24° 28' 32.5"
Beam size	0".08 X 0".06
Band	3

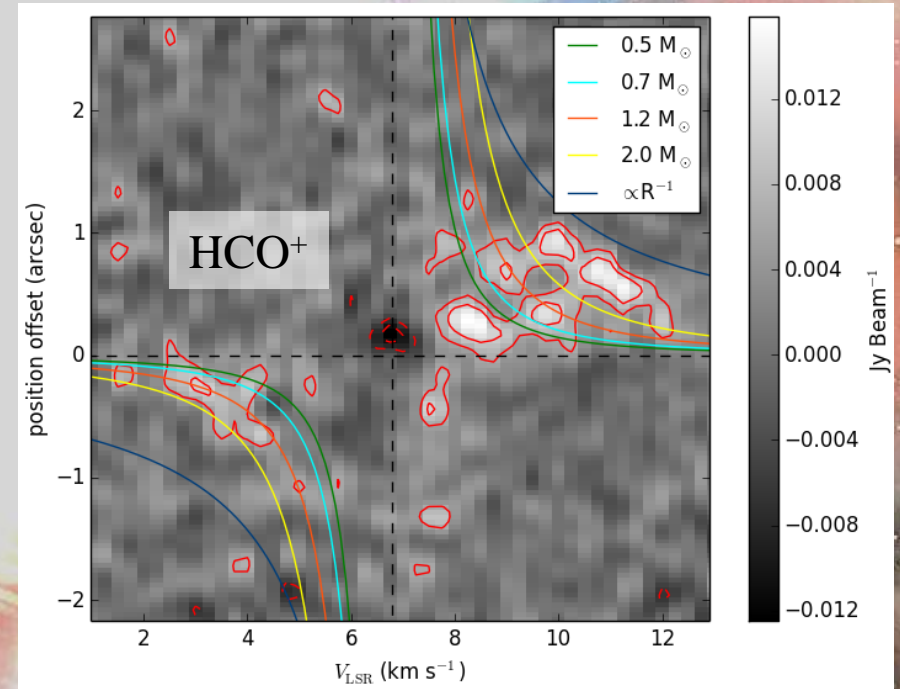
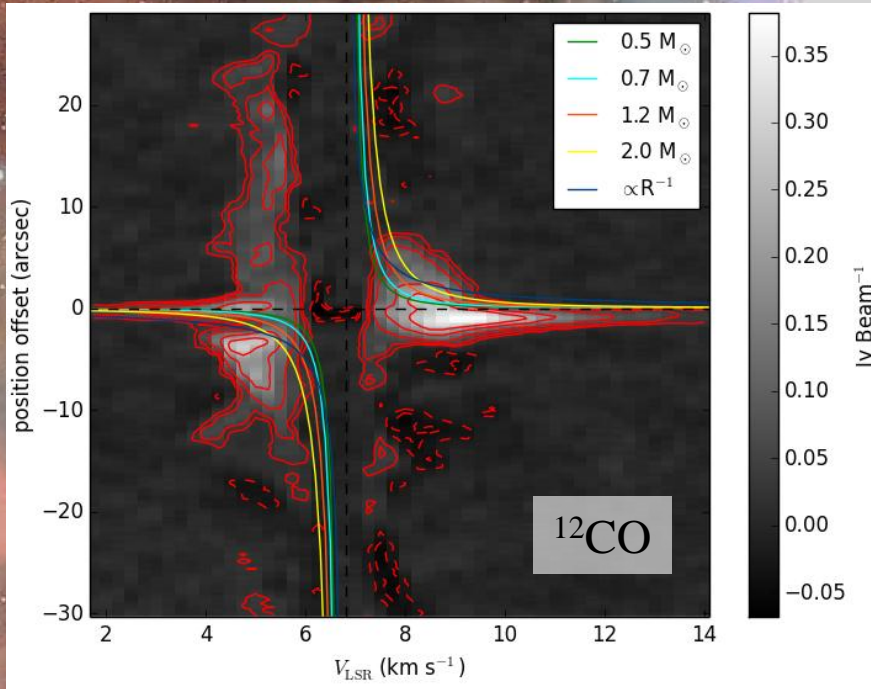


HL Tau moment maps



The figures show (left: $^{12}\text{CO}(J=1-0, \text{Band}3)$, right: $\text{HCO}^+(J=1-0, \text{Band}3)$), intensity (contours) and velocity (color-scale) integrated map of CO, contours are in steps of 3,5,7,10,20,30,40 σ with $\sigma = 8\text{mJy/beam}$ the intensity map of HCO⁺, contours are in steps of 3, 5, 10, 20 σ with $\sigma = 2\text{mJy/beam}$ blue contours: blue-shift; red contours: red-shift, red line: p-v cut

P-V diagrams of HL Tau



These figures show, left: ^{12}CO , right: HCO^+ with inclination angle red contours are in steps of 5, 10, 20, 30, 40 σ with $\sigma=10\text{mJy/beam}$ ^{12}CO . curves: the kepler's third law of, different colors represent different masses of the proto-star.(except blue line: infall)

Conclusions

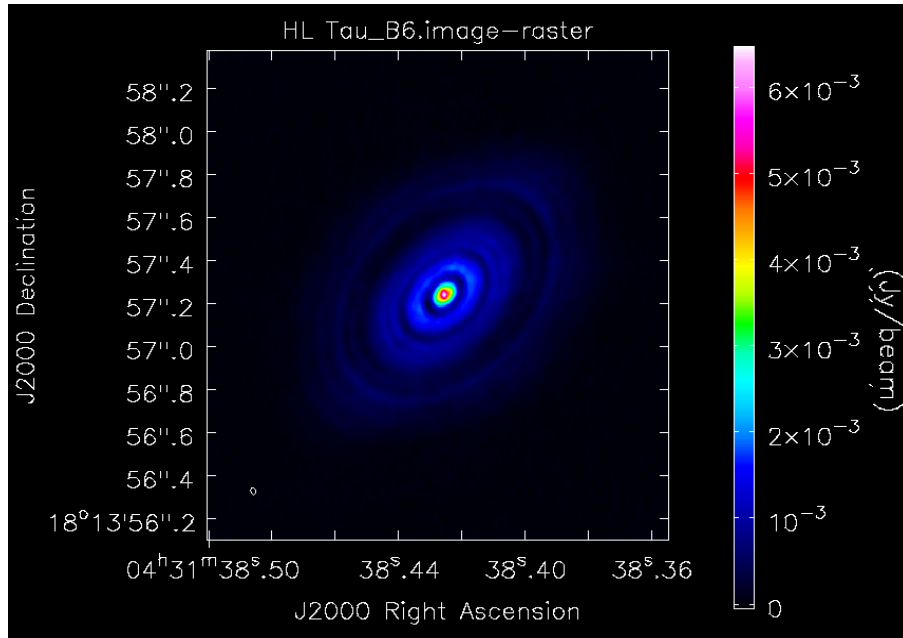
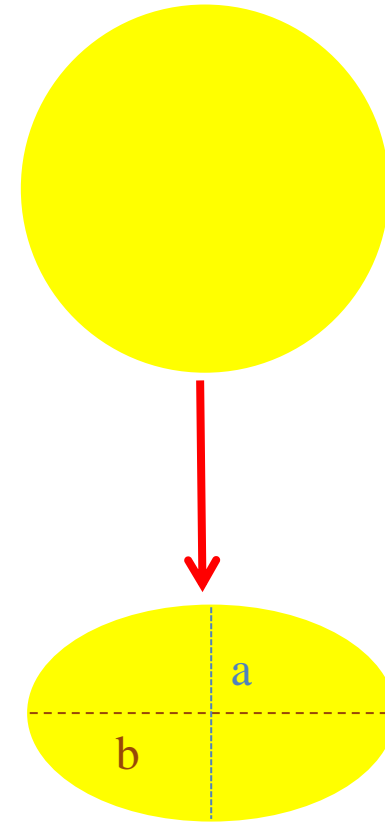
Protostar	Keplerian Disk
IRAS16293 A&B	×
VLA1623	✓
HD163296	✓
HL Tau	don't know

Protostar	Line	Keplerian motion?
VLA1623	C ¹⁸ O	✓
VLA1623	DCO ⁺	×
HD163296	¹² CO(J=2-1)	✓
HD163296	¹³ CO	✓
HD163296	C ¹⁸ O	✓
HD163296	¹² CO(J=3-2)	×
HL Tau	¹² CO	×
HL Tau	HCO ⁺	?



**This is the end of my presentation,
thank you for your listening!!**

Assume thin disk



$$\frac{a}{b} = \cos i$$

i: inclination angle