2017 UCTA Summer Student Program

(1)Digging in the ALMA data archive
(2)Searching for young proto-planetary disks from ALMA archival data

Supervisor: Shih-Ping Lai (賴詩萍)

Speaker: Hua- Hsuan Chen(陳華選)

outline

introduction

Example (analysis)

conclusion

Keplerian disk

- We use moment map to study every disk ,if the disk obeys kepler's law ,we call it keplerian disk .It obey's the following equation

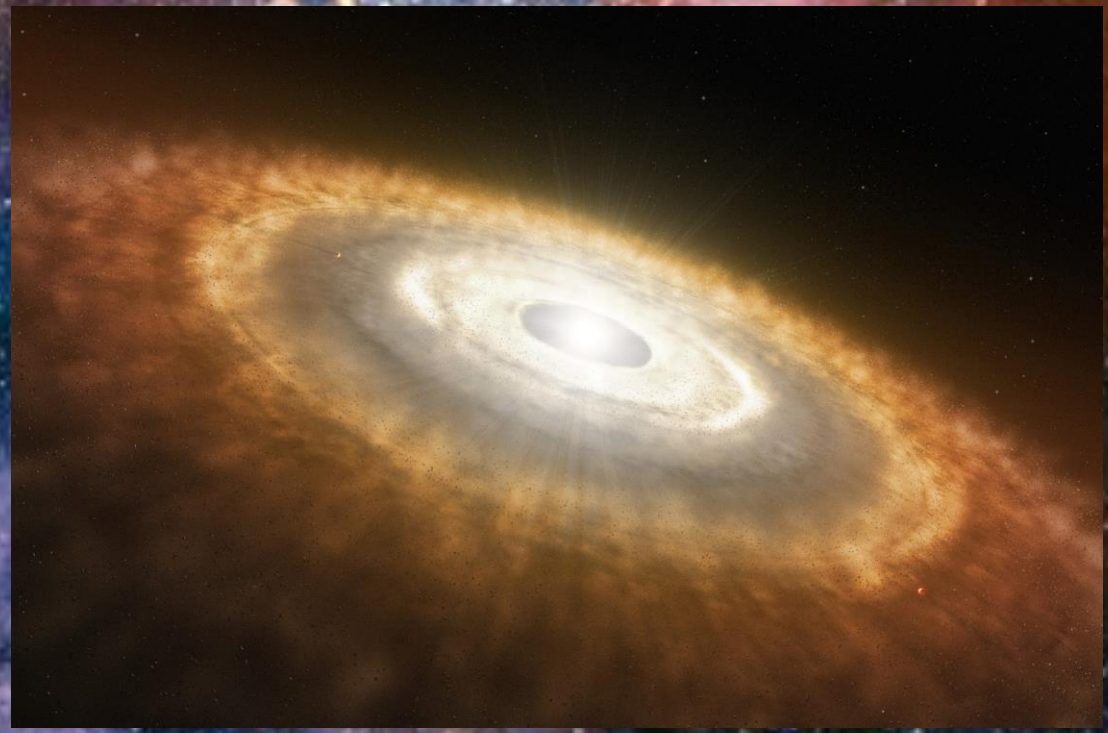
$$v = \sqrt{\frac{Gm}{r}}$$

v : velocity of the molecular

G : gravitational constant

m : protostellar mass

r : radius at which the velocity is being measured



Keplerian curve

- A kind of curve that obeys kepler's law, and is inversely proportional to the square root of its distance from the center
- It can used to measure the mass of the source

column density

- It means the quantity of molecular or matter per unit area, and we can use it to times the area of the disk to estimate the mass of the disk
- Besides ,column density is based on radiative transfer and collisional excitation of molecules

column density

The column density N is equal to

$$N_{tot}(\mathrm{C18O})=\frac{3*h}{8*\pi^3*u^2*J_u*R_i}\left(\frac{k*T_{ex}}{h*B}+\frac{1}{3}\right)\exp\left(\frac{E_u}{k*T_{ex}}\right)\left[\exp\left(\frac{h*v}{k*T_{ex}}\right)-1\right]^{-1}\int dv\,\tau_v$$

E_u=15.81K(C18O,2-1)
T_{ex}=10K
u=1.1079*10^{-19}
J_u=2(C18O,2-1)
R_i=1
B=54891.42(MHz)

program

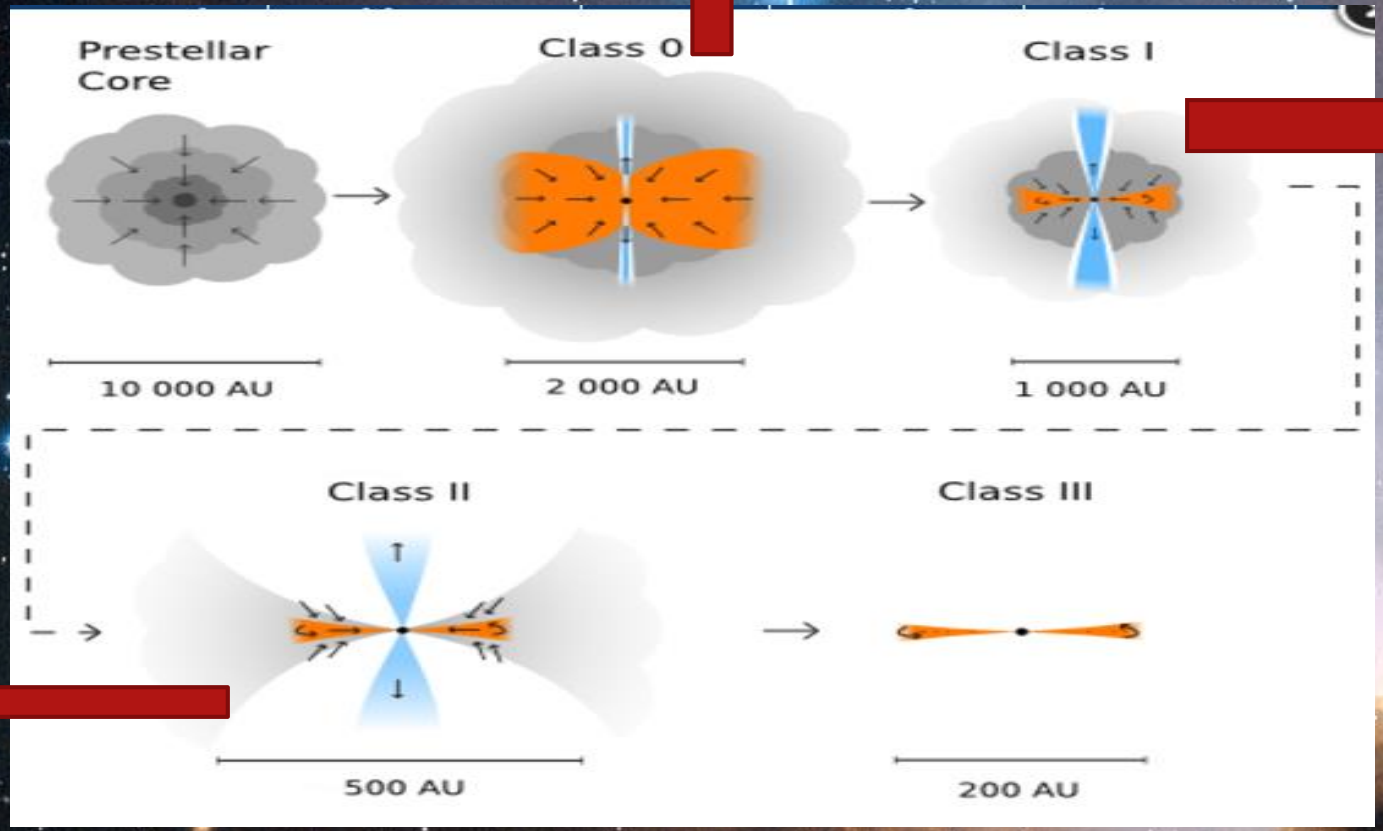
- Read header
- Calculate column density
- Draw keplerian curve

casa

- Moment map
- Position-velocity diagram
- Importfits and exportfits

Star formation

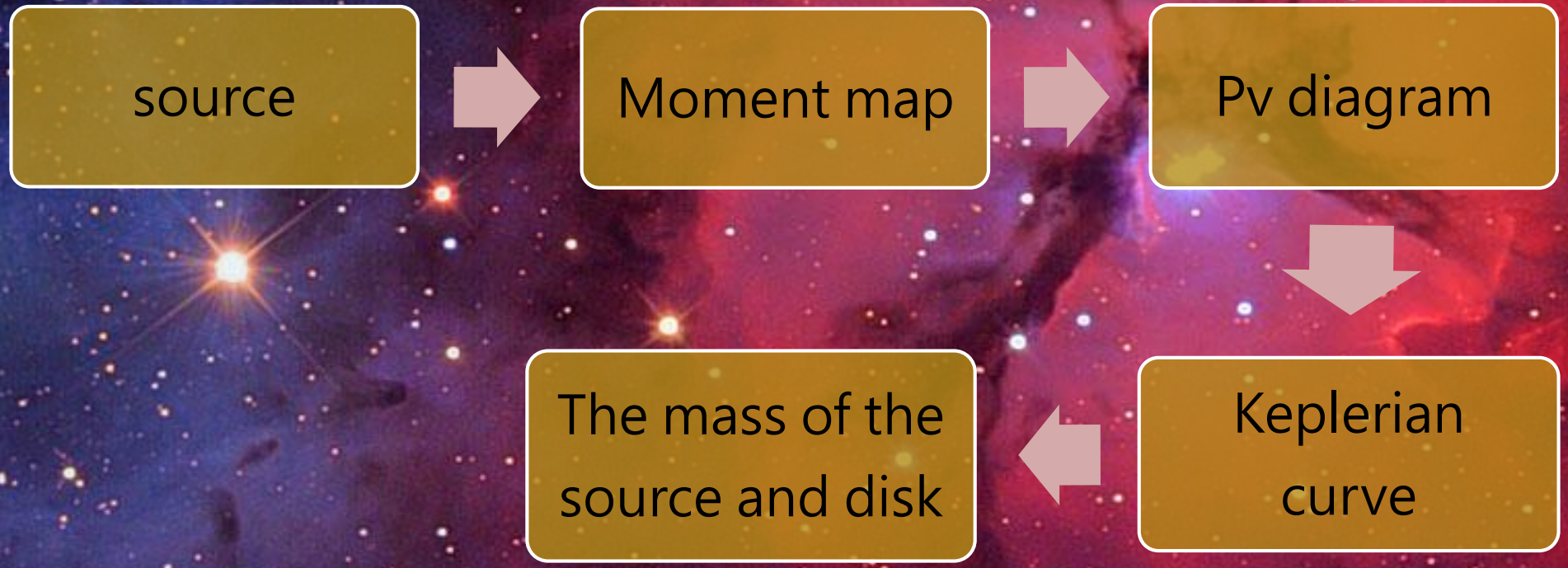
serpens_smm4



DG tau B

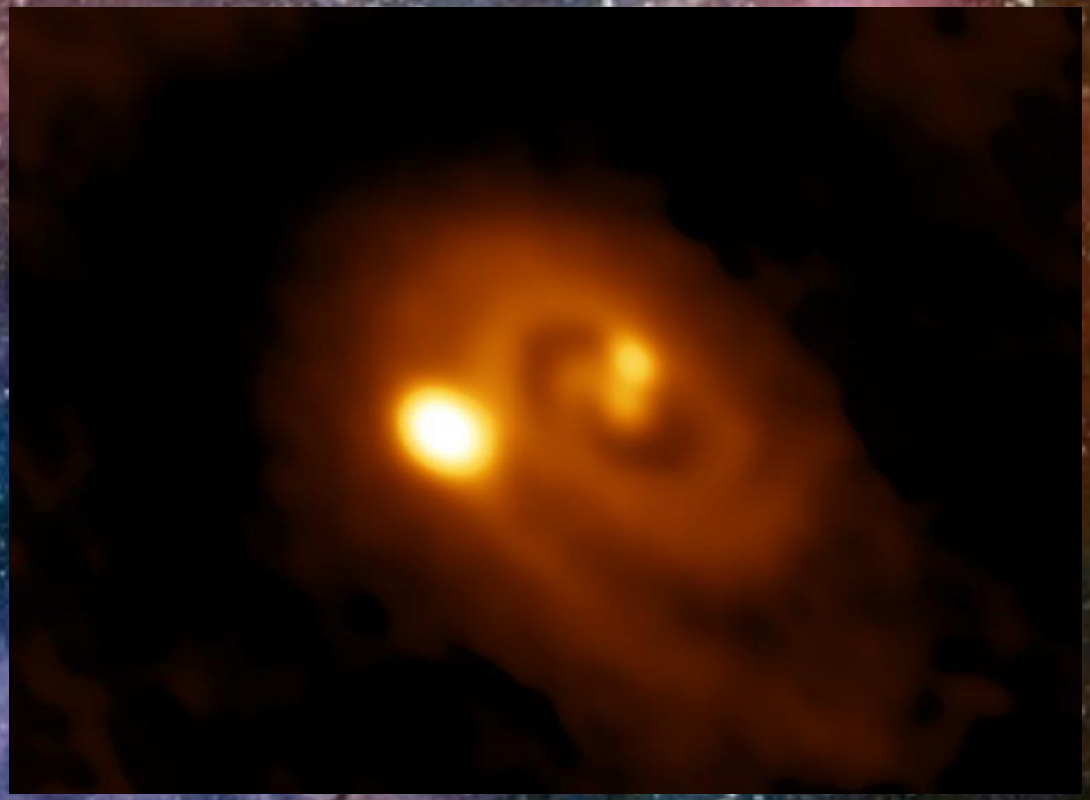
IRS_48

outline2

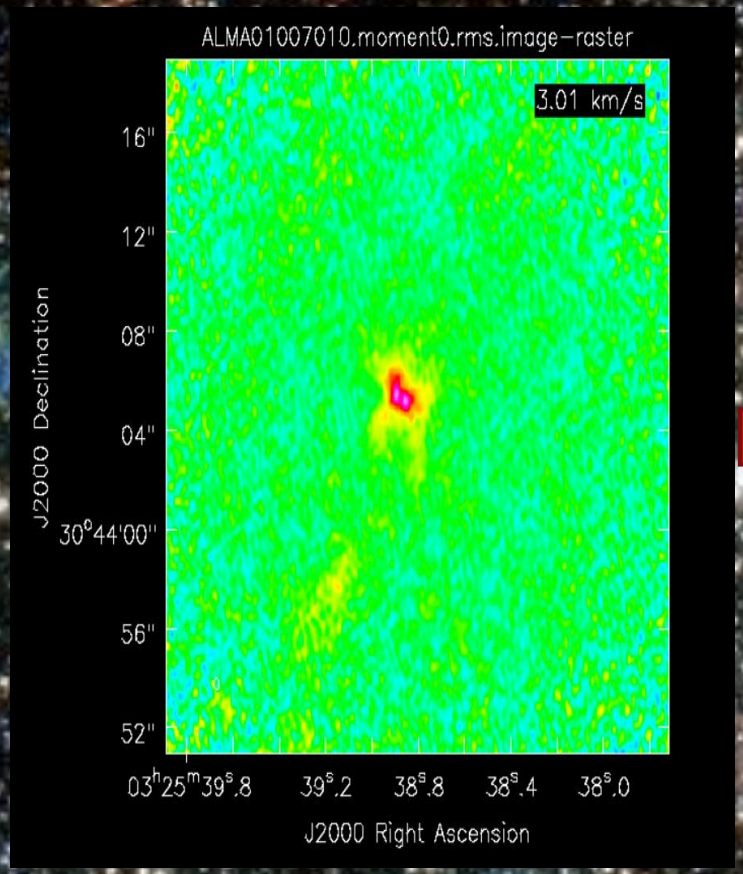

source
Moment map
Pv diagram
Keplerian curve
The mass of the source and disk

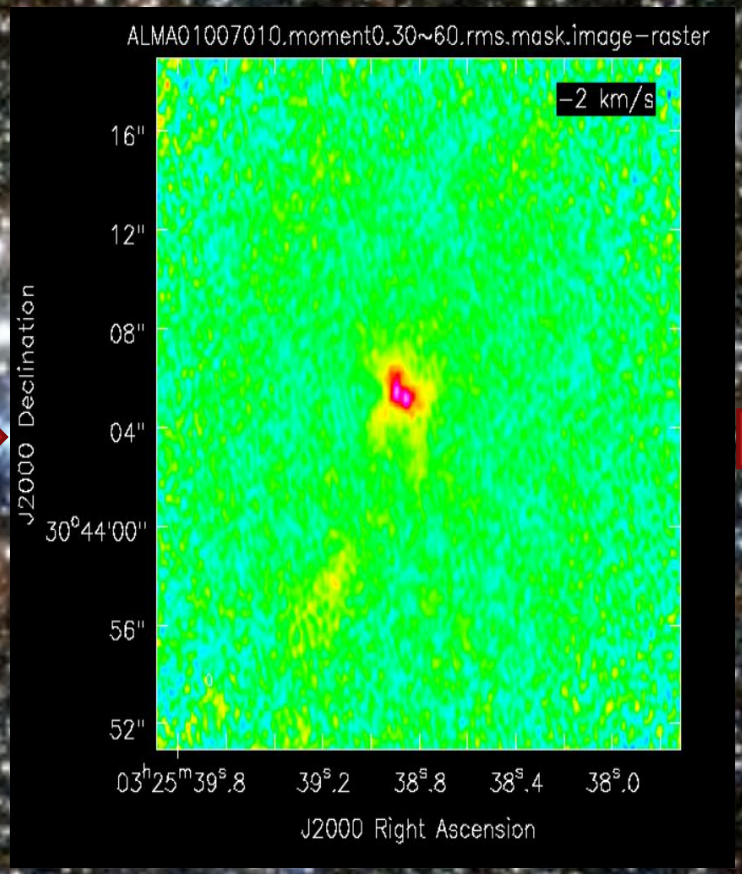
Example: L1448

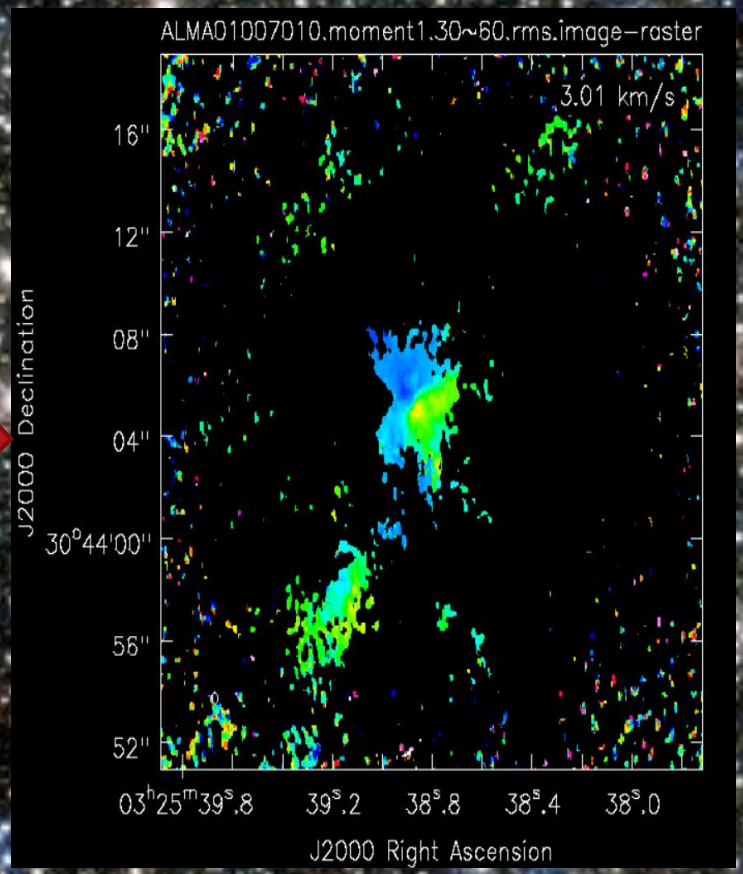
center:03h25m38.8 30d44m04
Class 0
System: triple protostar System
Spectrum: C18O(2-1)



Moment map

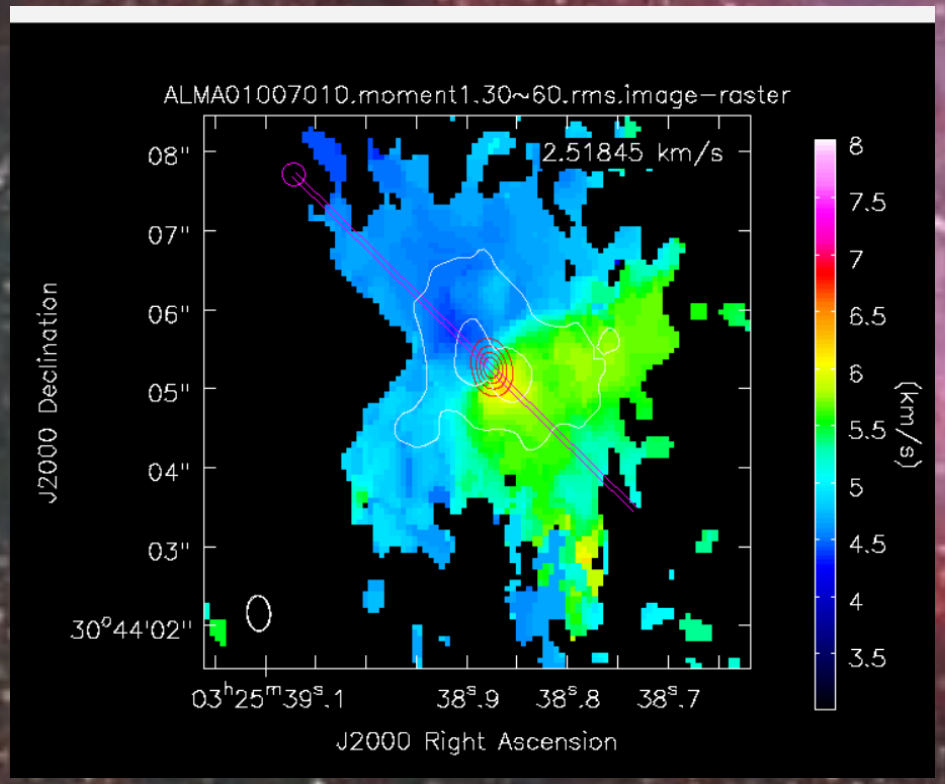

ALMA01007010.moment0.rms.image-raster
3.01 km/s
16"
12"
08"
04"
30°44'00"
56"
52"
J2000 Declination
03h25m39s.8
39s.2
38s.8
38s.4
38s.0
J2000 Right Ascension


ALMA01007010.moment0.30~60.rms.mask.image-raster
-2 km/s
16"
12"
08"
04"
30°44'00"
56"
52"
J2000 Declination
03h25m39s.8
39s.2
38s.8
38s.4
38s.0
J2000 Right Ascension

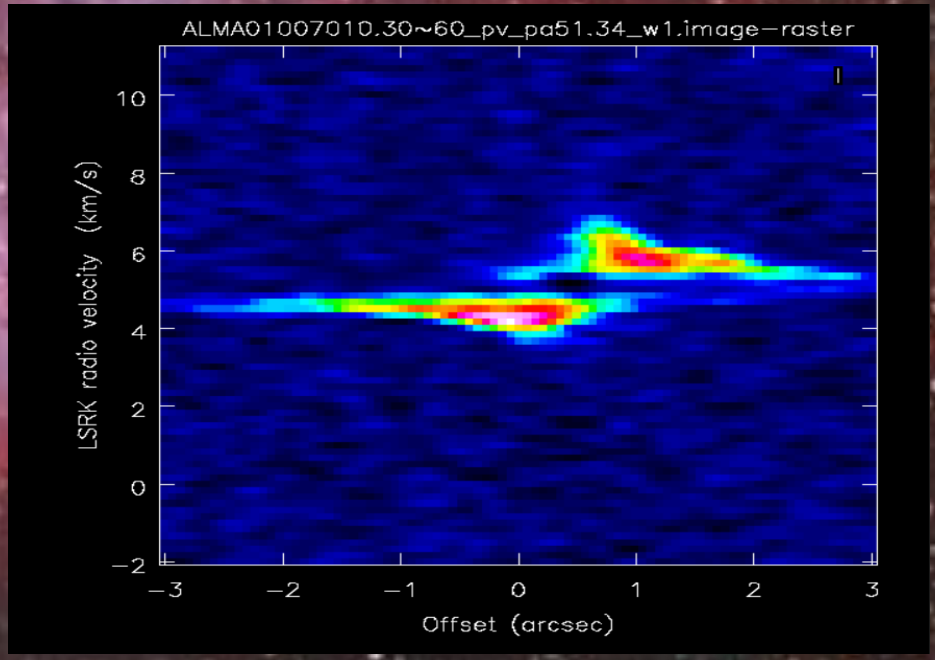

ALMA01007010.moment1.30~60.rms.image-raster
3.01 km/s
16"
12"
08"
04"
30°44'00"
56"
52"
J2000 Declination
03h25m39s.8
39s.2
38s.8
38s.4
38s.0
J2000 Right Ascension

Position-velocity diagram

(1) We can use it to diagnose whether it is a keplerian disk

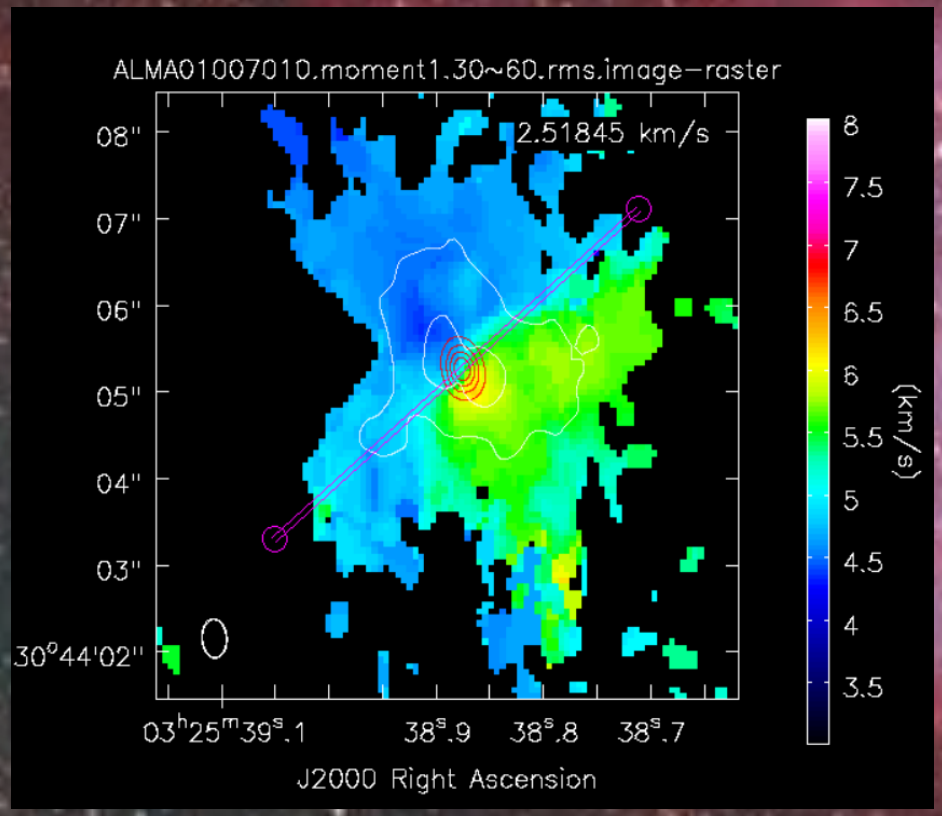


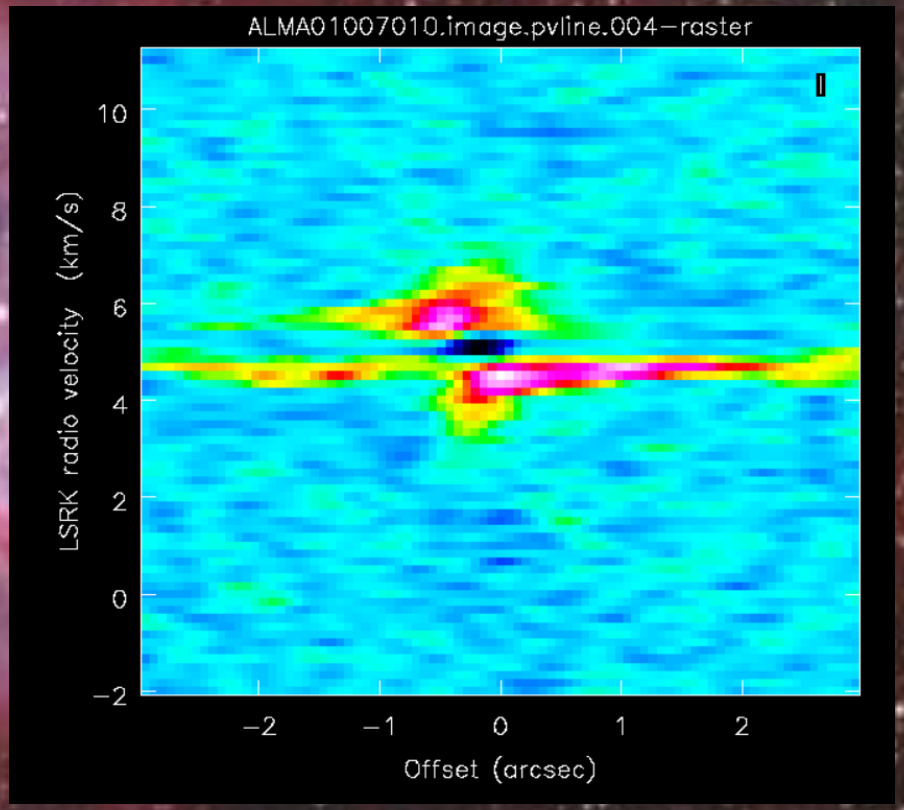
Pa=51.34



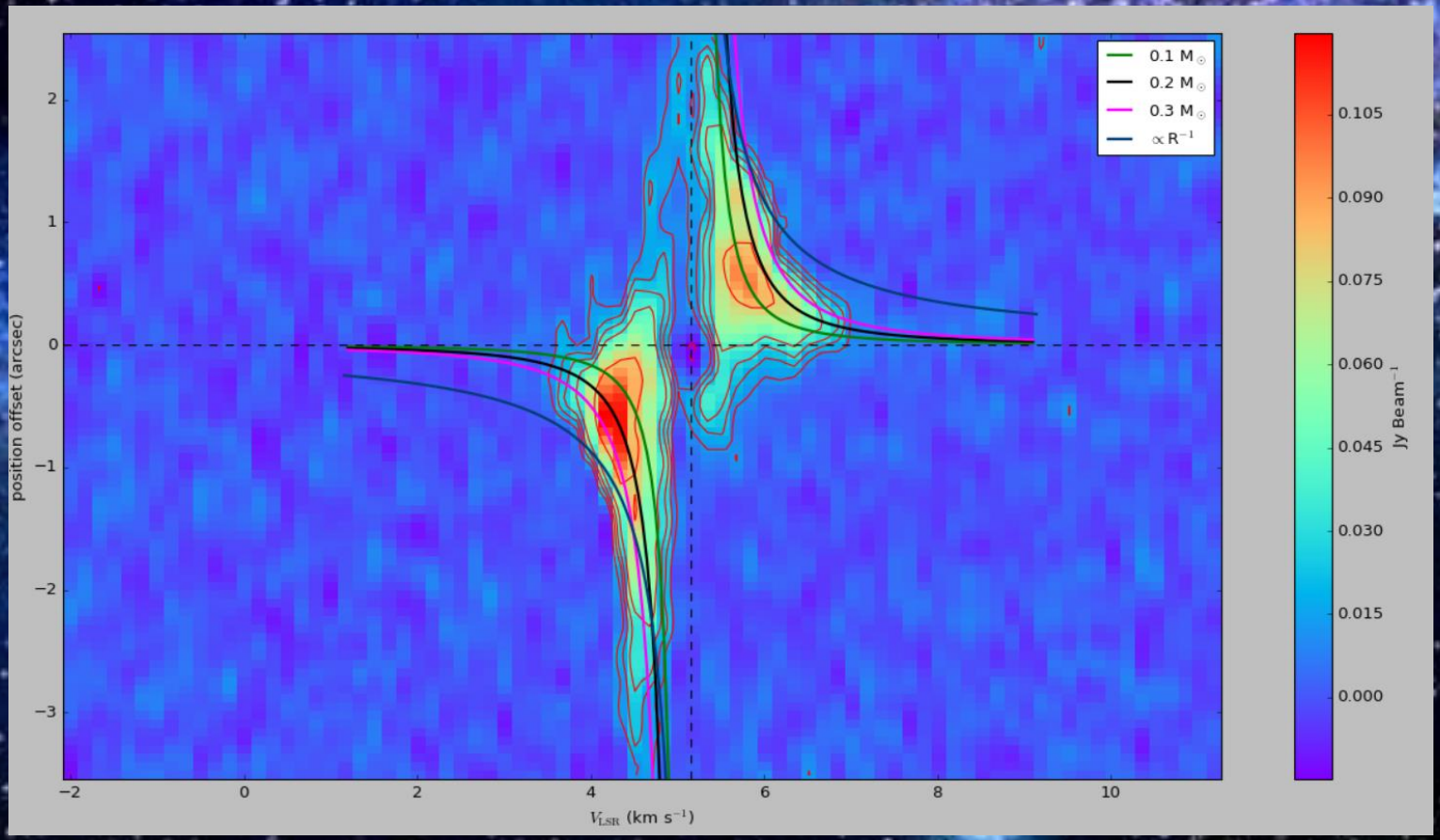
Position-velocity diagram

Pa=-40.91





Keplerian curve



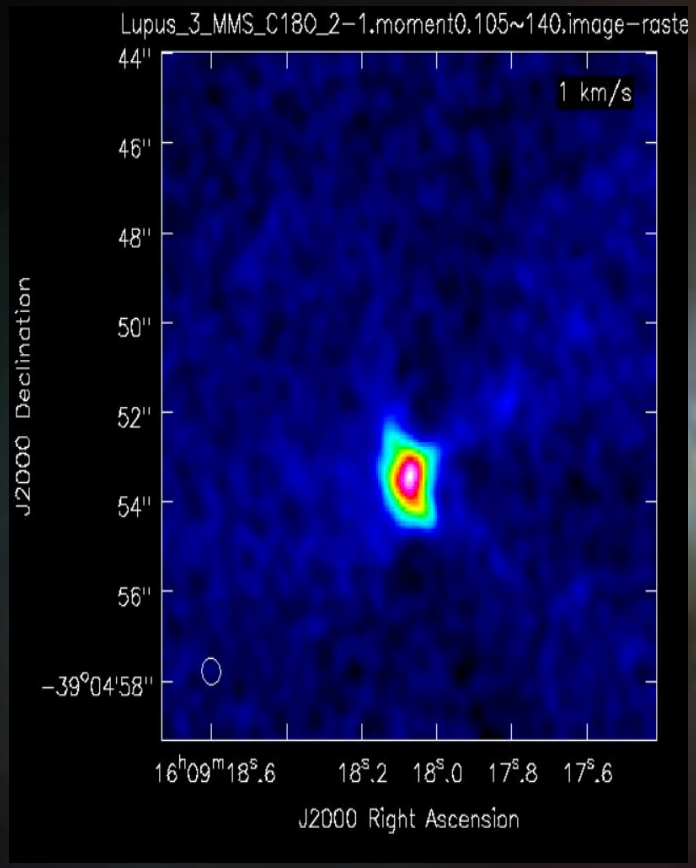
The mass of the disk

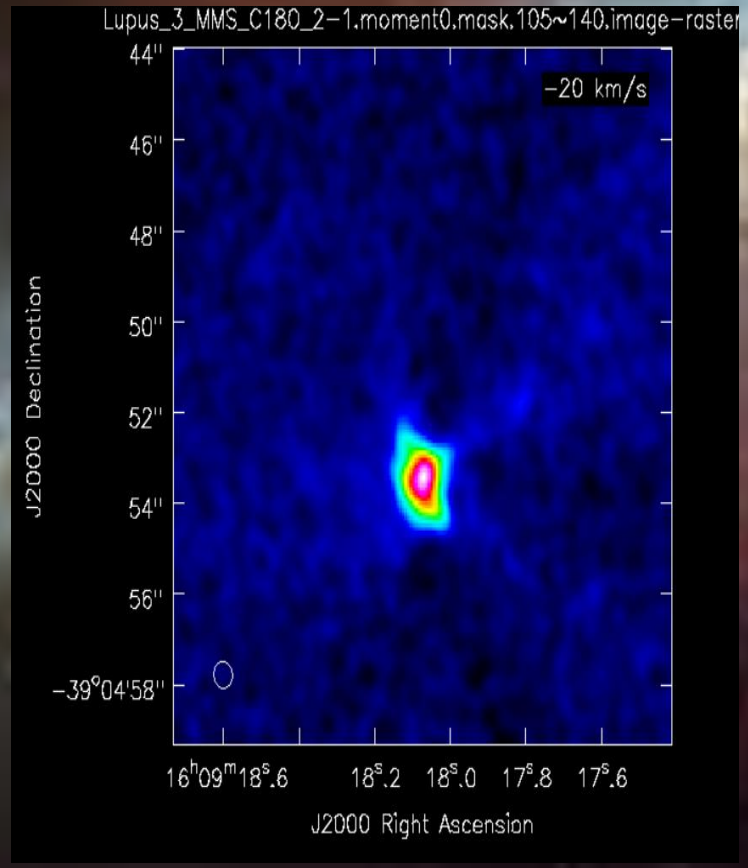
- I use column density to calculate the quantity of the molecular per cm^2,and use this to calculate the mass of the disk.
- Therefore I calculate the mass of the disk(L1448) for 0.045 solar mass.

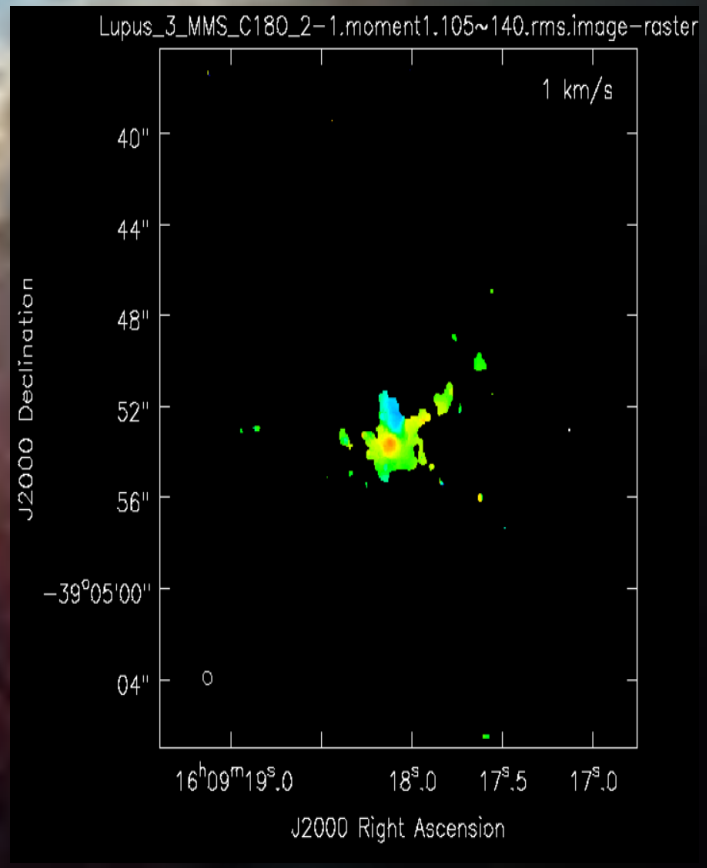
Example:Lupus3 MMS

System: fourth protostar system
Center:4h31m44.5 18d8
Class:0
Spectrum:C18O(2-1)

Moment map

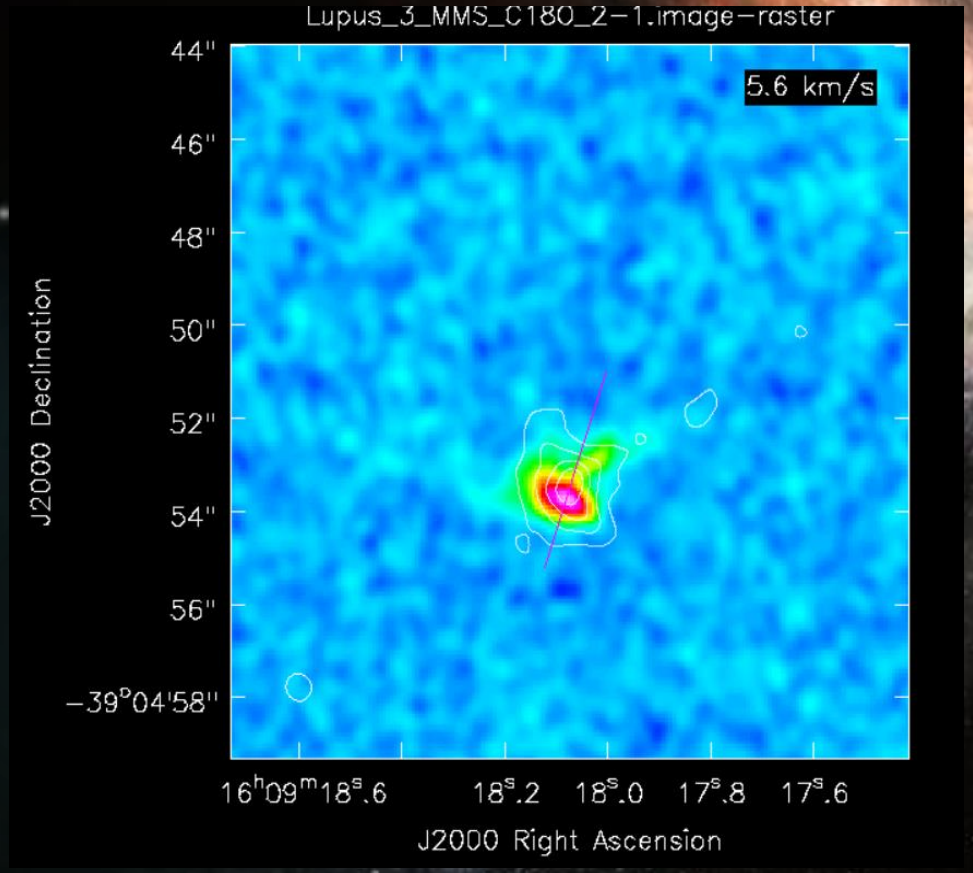

Lupus_3_MMS_C180_2-1.moment0.105~140.image-raste
1 km/s
44''
46''
48''
50''
52''
54''
56''
-39°04'58''
J2000 Declination
16h09m18s.6
18s.2
18s.0
17s.8
17s.6
J2000 Right Ascension

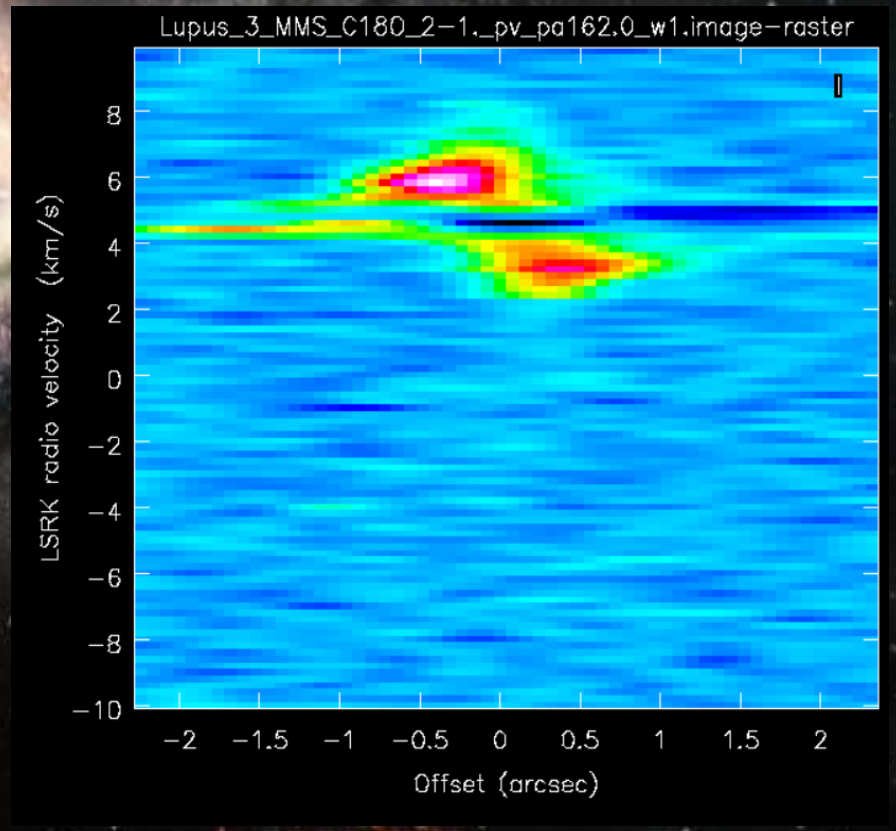

Lupus_3_MMS_C180_2-1.moment0.mask.105~140.image-raster
-20 km/s
44''
46''
48''
50''
52''
54''
56''
-39°04'58''
J2000 Declination
16h09m18s.6
18s.2
18s.0
17s.8
17s.6
J2000 Right Ascension


Lupus_3_MMS_C180_2-1.moment1.105~140.rms.image-raster
1 km/s
40''
44''
48''
52''
56''
-39°05'00''
04''
J2000 Declination
16h09m19s.0
18s.0
17s.5
17s.0
J2000 Right Ascension

Pv diagram

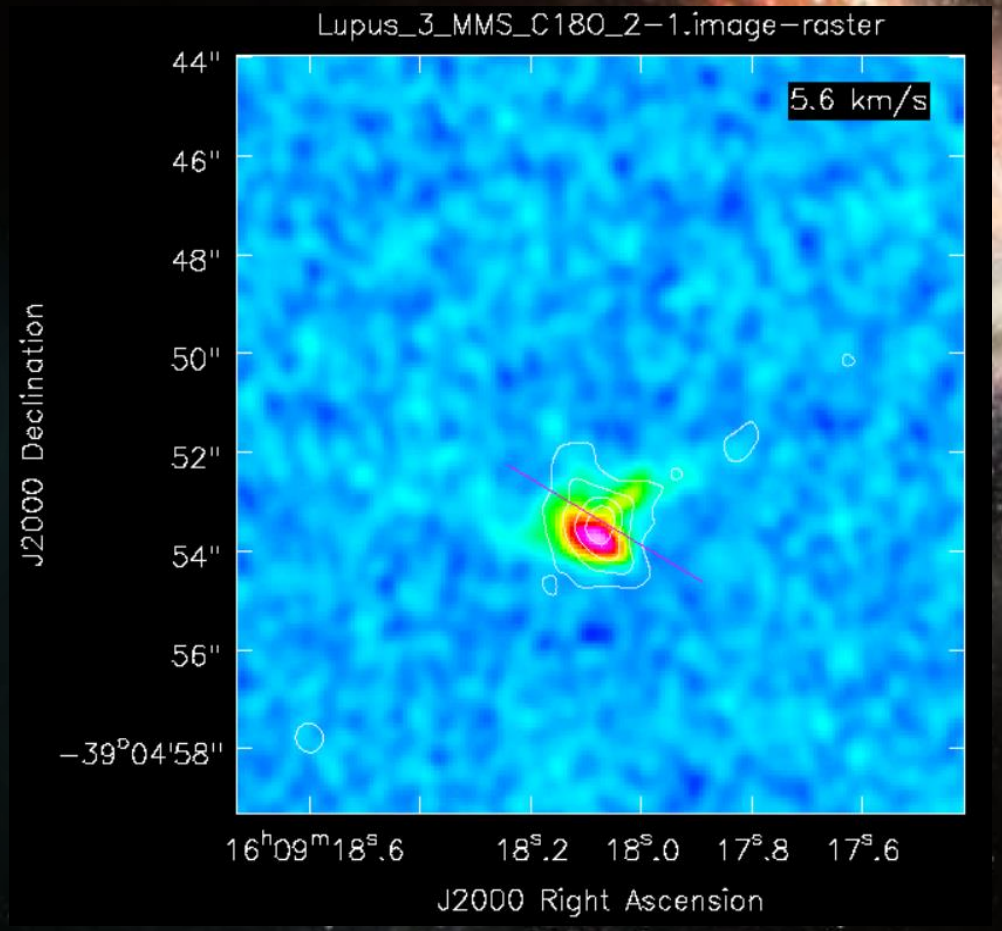
Pa=162

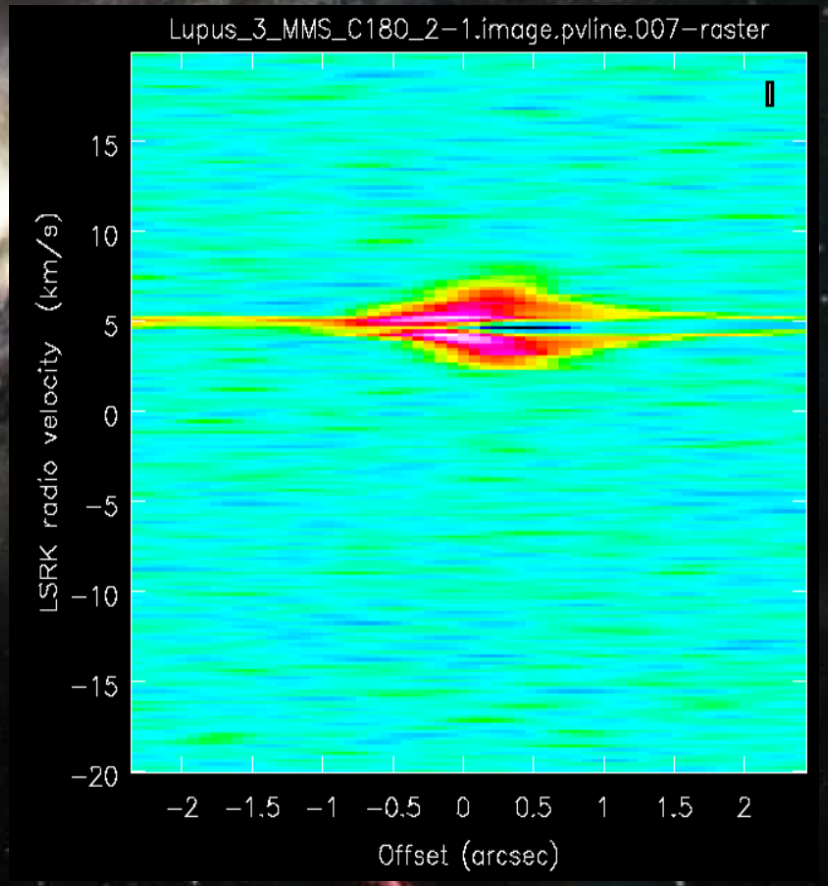




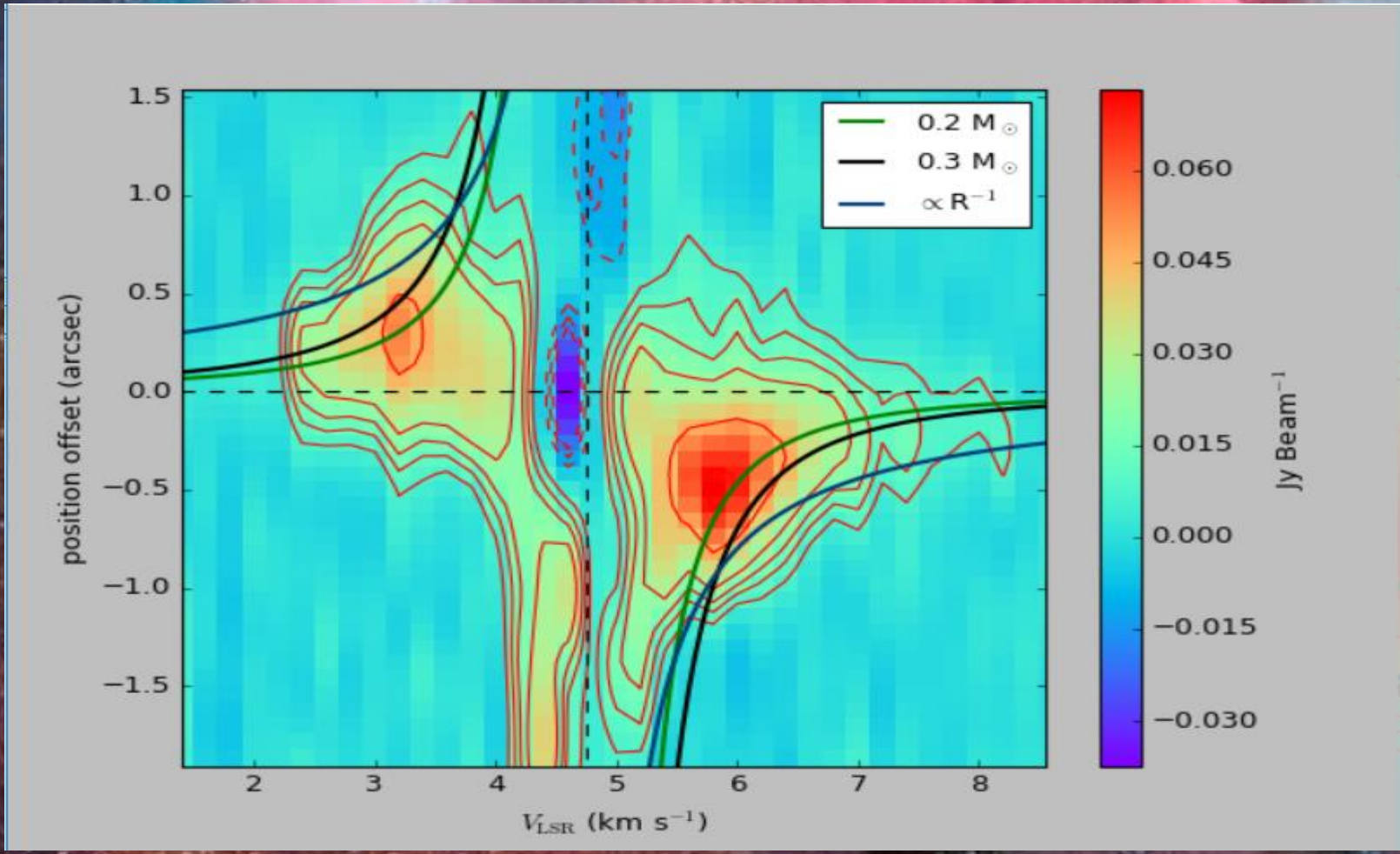
Pv diagram

Pa=60



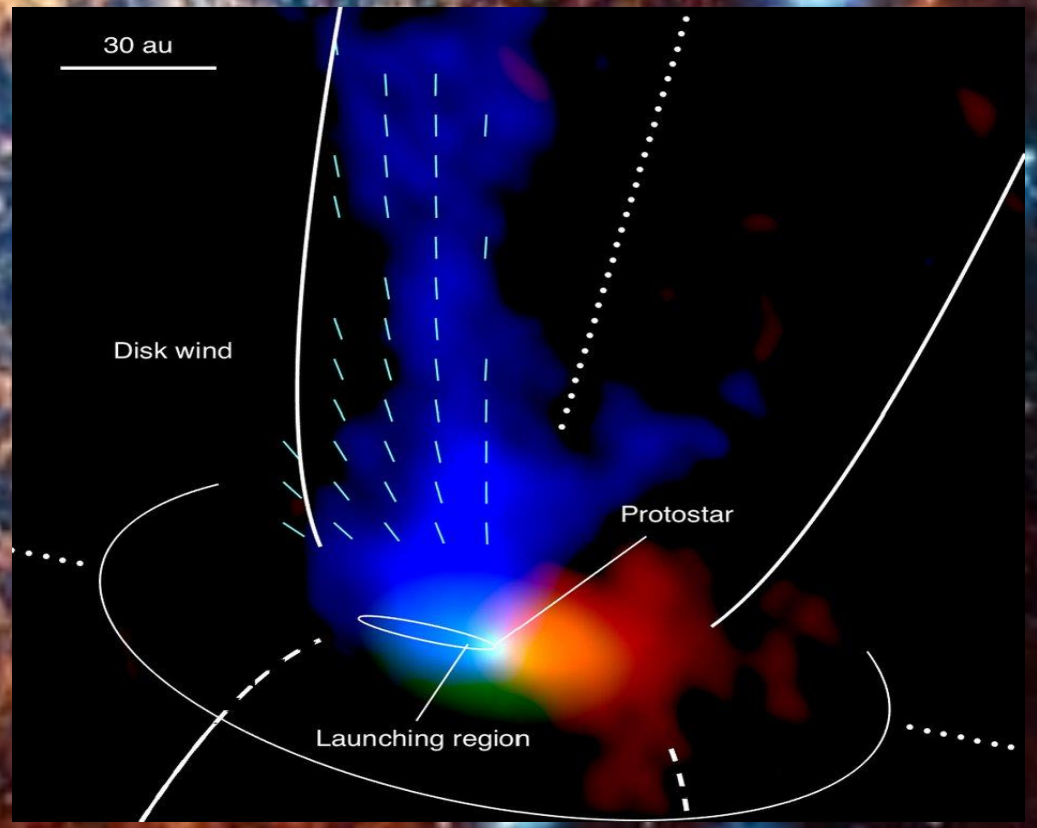


Keplerian curve

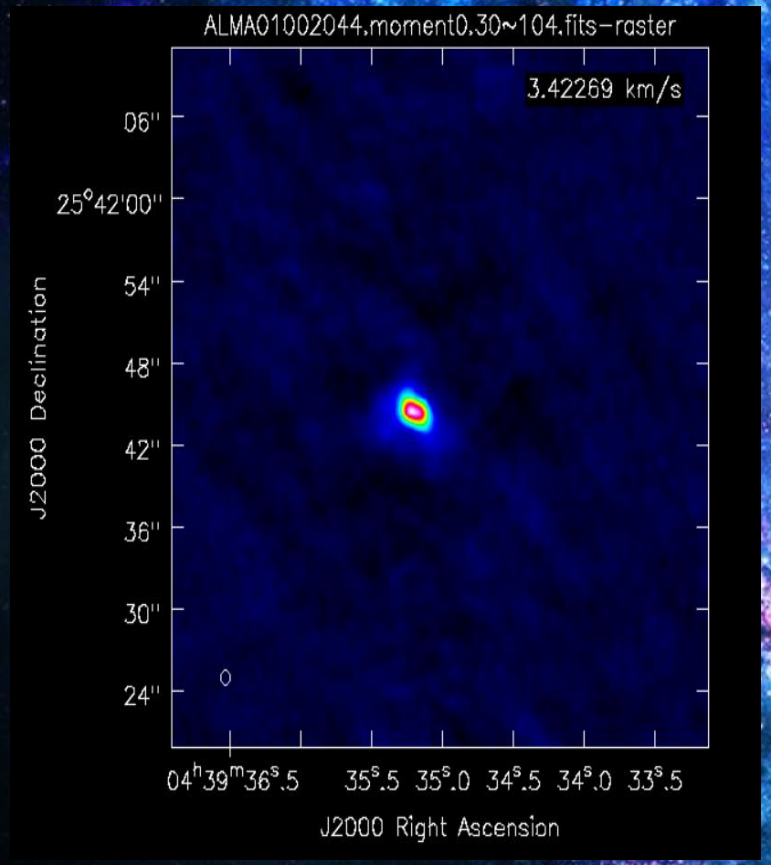


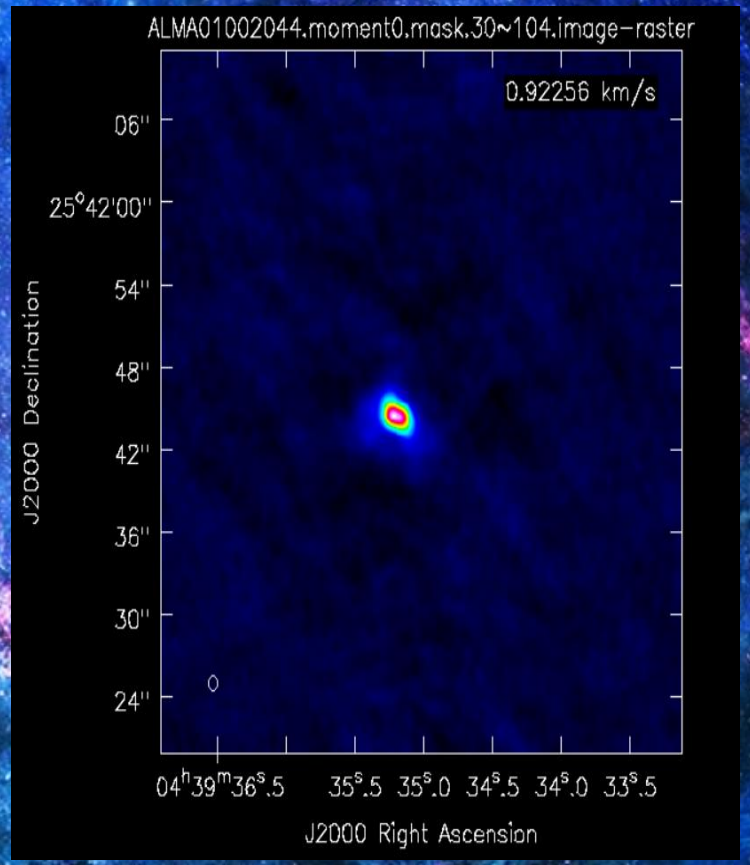
Example:TMC1A

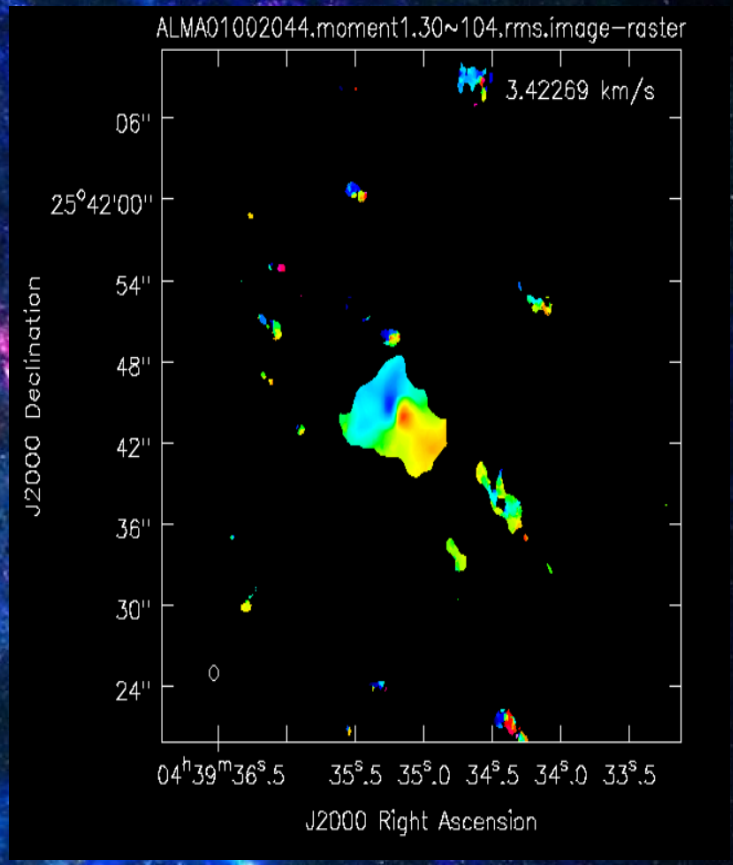
System: binary protostar system
Center:04h39m53.9 +26d03m09
Class:1
Spectrum:C18O(2-1)



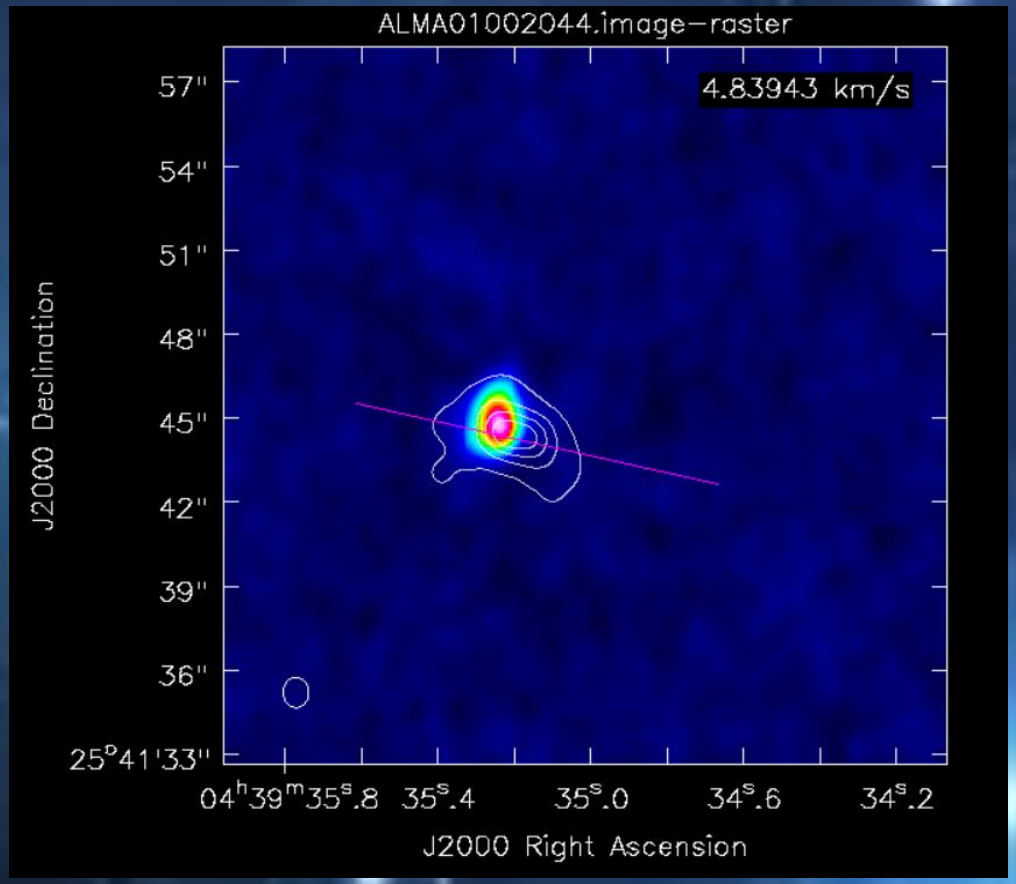
Moment map


ALMA01002044.moment0.30~104.fits-raster
3.42269 km/s
06"
25°42'00"
54"
48"
42"
36"
30"
24"
J2000 Declination
04h39m36s.5
35s.5
35s.0
34s.5
34s.0
33s.5
J2000 Right Ascension

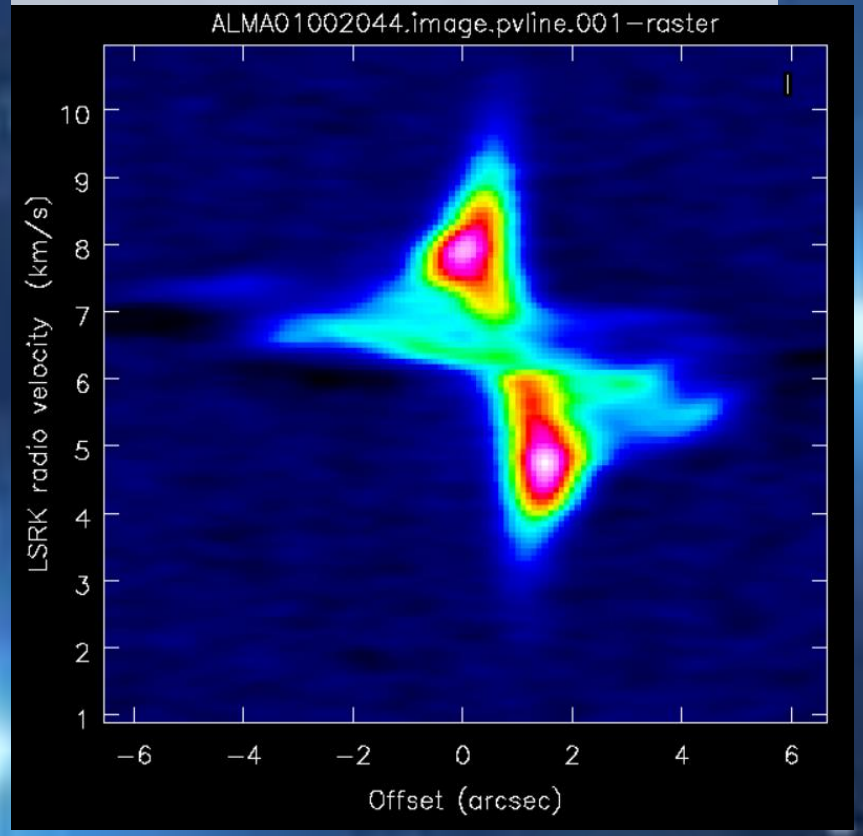

ALMA01002044.moment0.mask.30~104.image-raster
0.92256 km/s
06"
25°42'00"
54"
48"
42"
36"
30"
24"
J2000 Declination
04h39m36s.5
35s.5
35s.0
34s.5
34s.0
33s.5
J2000 Right Ascension


ALMA01002044.moment1.30~104.rms.image-raster
3.42269 km/s
06"
25°42'00"
54"
48"
42"
36"
30"
24"
J2000 Declination
04h39m36s.5
35s.5
35s.0
34s.5
34s.0
33s.5
J2000 Right Ascension

Pv diagram

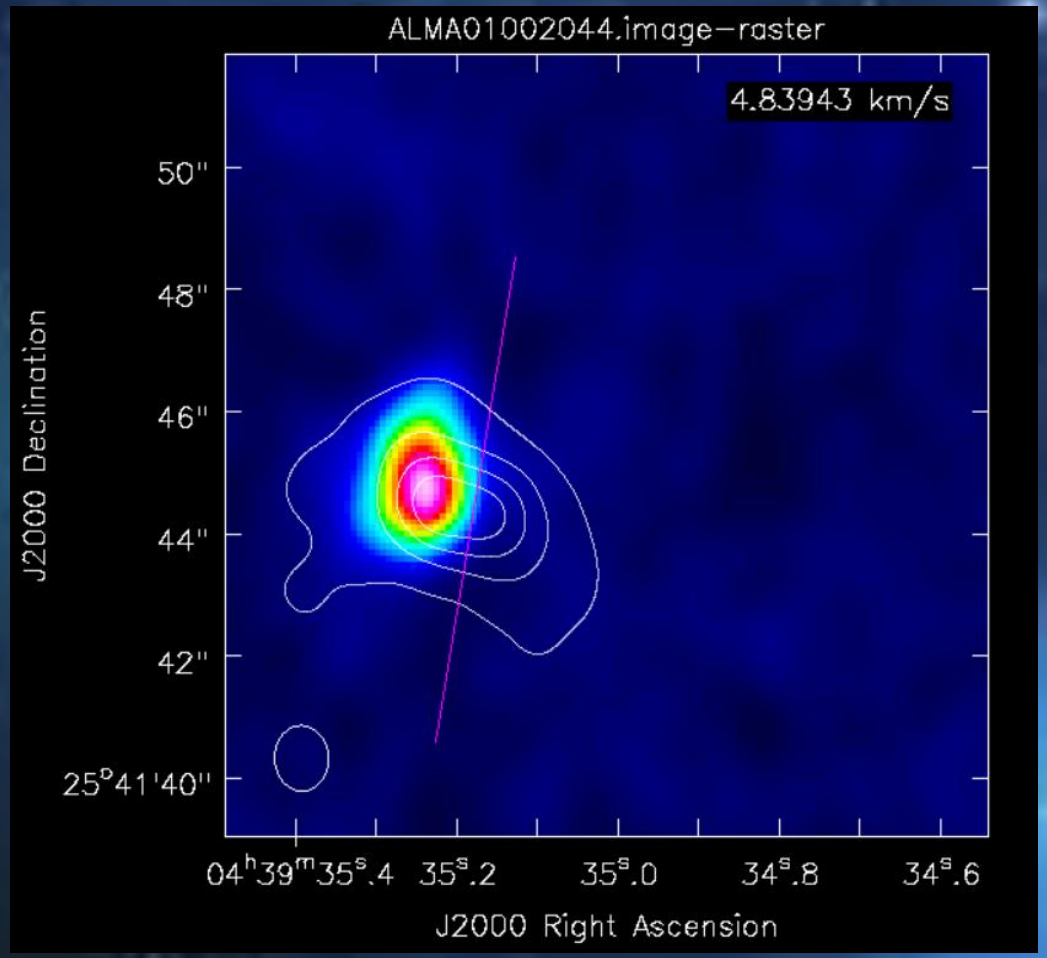


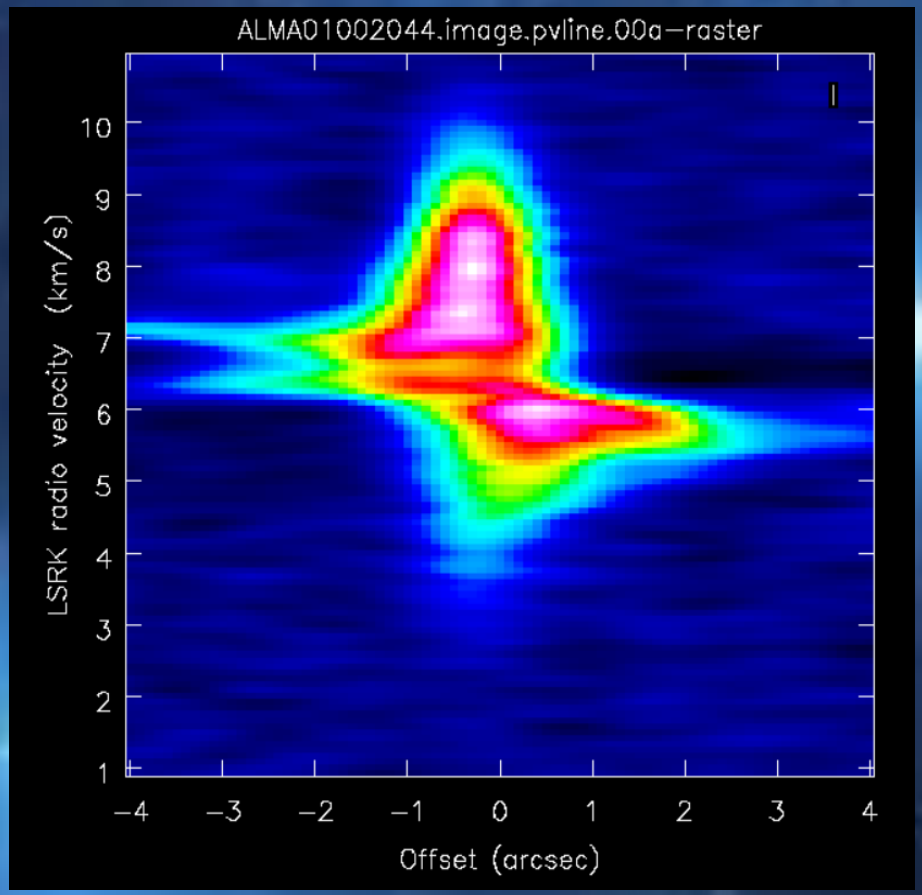
Pa=77.3



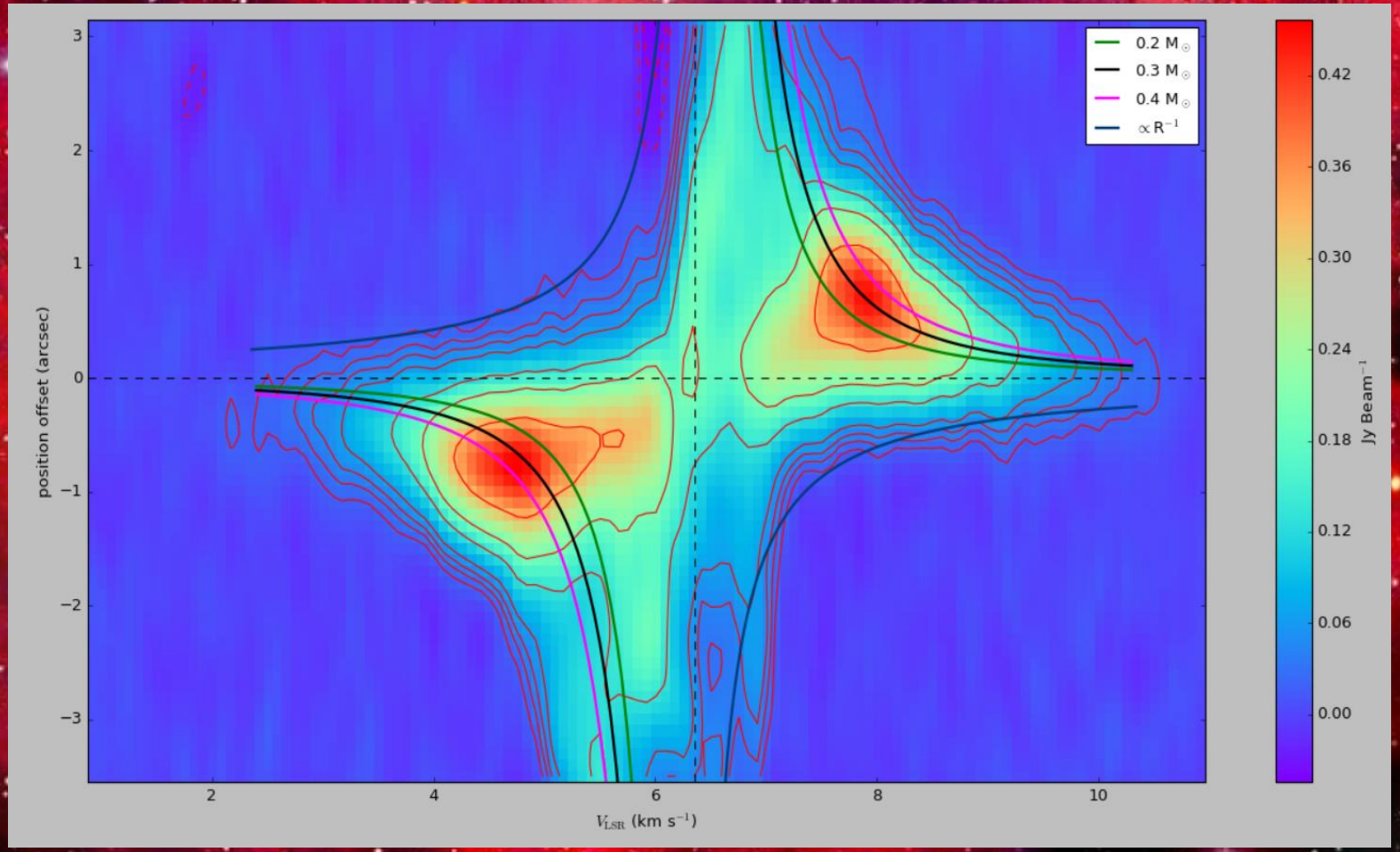
Pv diagram

Pa=170.4





Keplerian curve



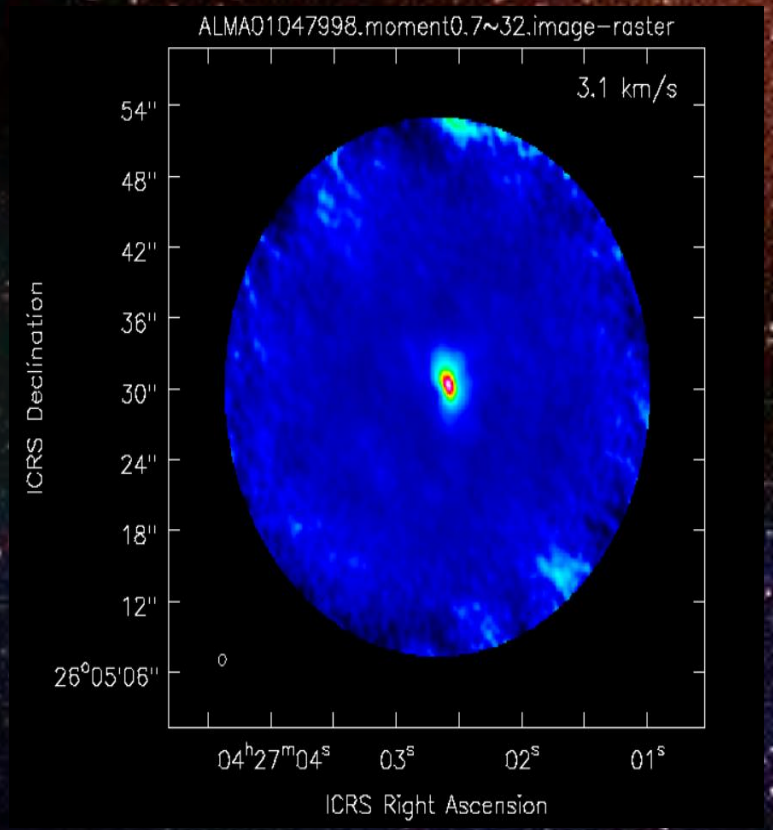
The mass of the disk

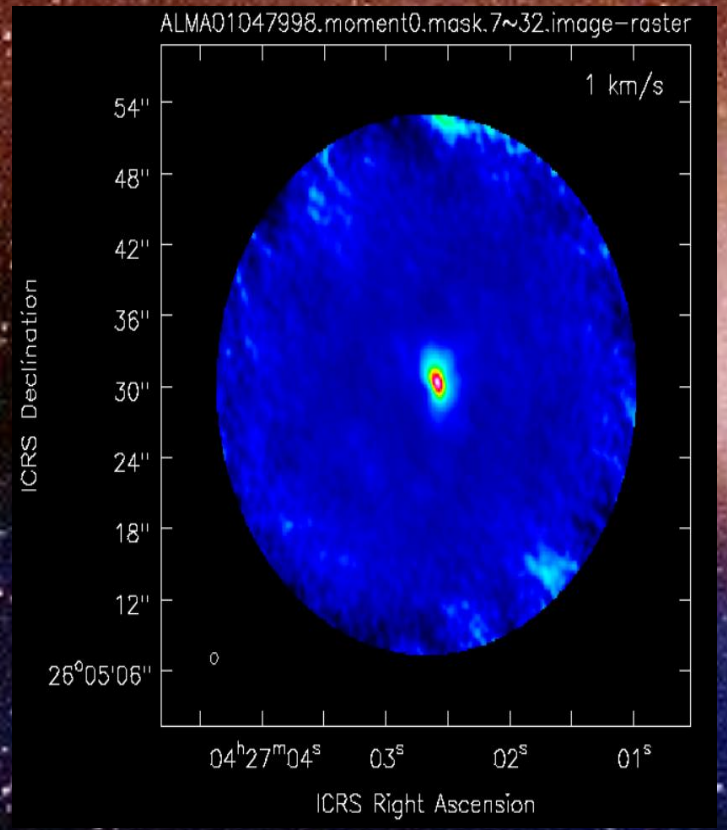
- I use column density to calculate the quantity of the molecular per cm^2 ,and use this to calculate the mass of the disk.
- Therefore I calculate the mass of the disk(TMC1A) for 0.01875 solar mass.

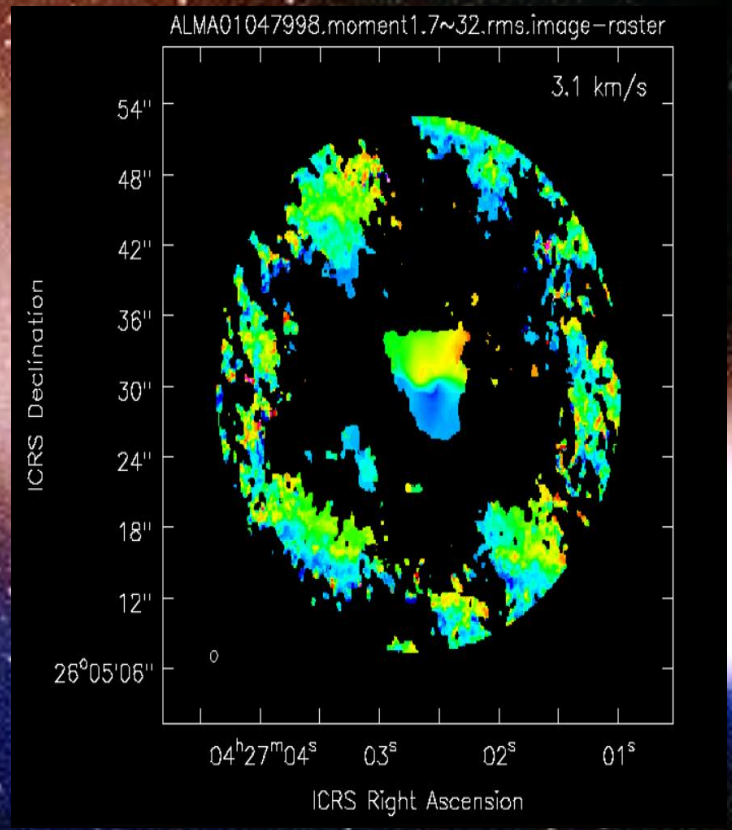
Example: DG TAU B

System: single protostar system
Center:04h27m02.6 +26d05m29
Class:1
Spectrum:13CO(2-1)

Moment map

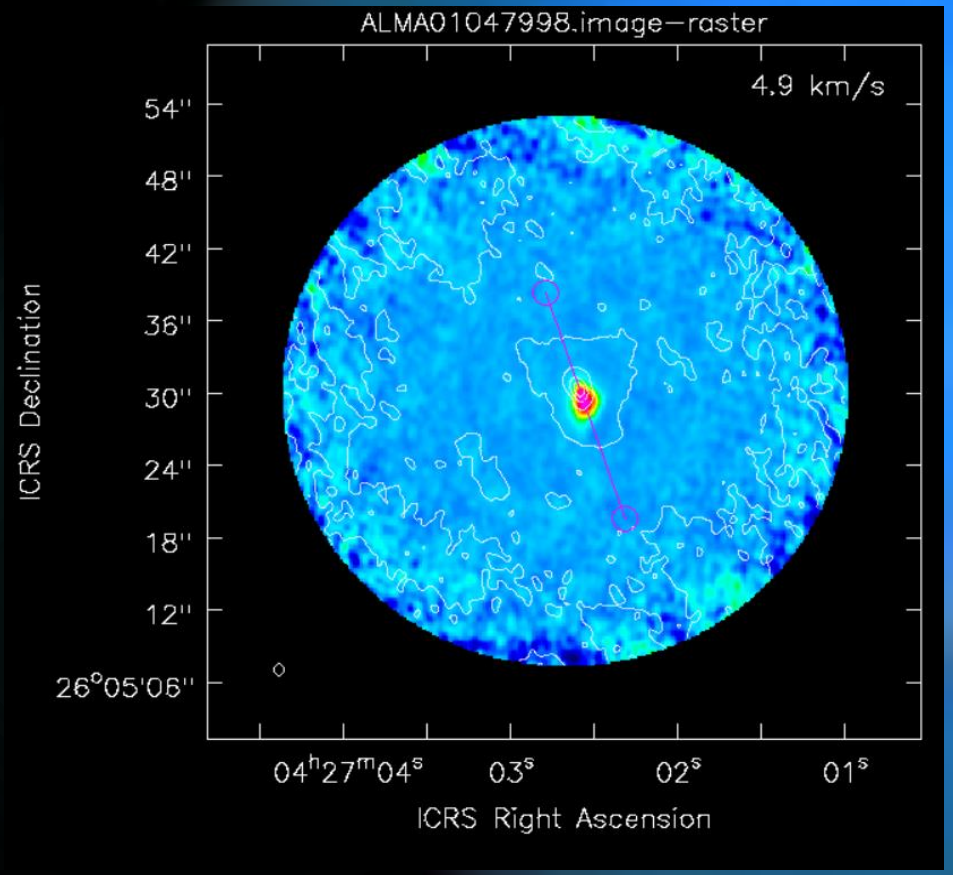

ALMA01047998.moment0.7~32.image-raster
3.1 km/s
54''
48''
42''
36''
30''
24''
18''
12''
26°05'06''
ICRS Declination
04h27m04s
03s
02s
01s
ICRS Right Ascension

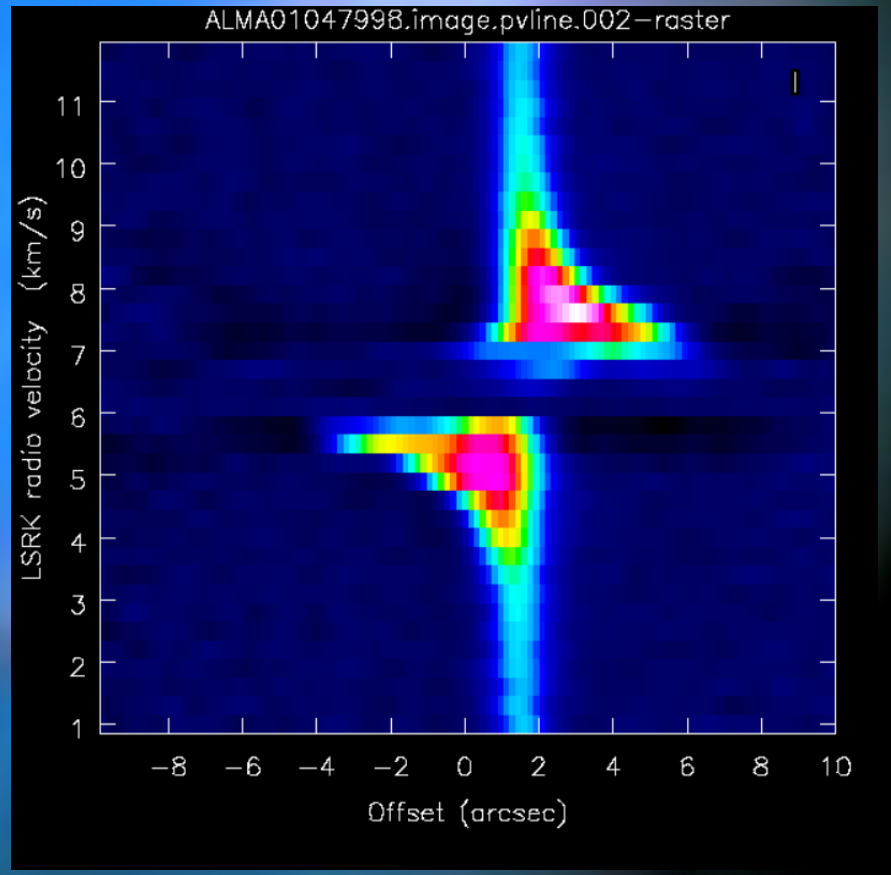

ALMA01047998.moment0.mask.7~32.image-raster
1 km/s
54''
48''
42''
36''
30''
24''
18''
12''
26°05'06''
ICRS Declination
04h27m04s
03s
02s
01s
ICRS Right Ascension


ALMA01047998.moment1.7~32.rms.image-raster
3.1 km/s
54''
48''
42''
36''
30''
24''
18''
12''
26°05'06''
ICRS Declination
04h27m04s
03s
02s
01s
ICRS Right Ascension

Pv diagram

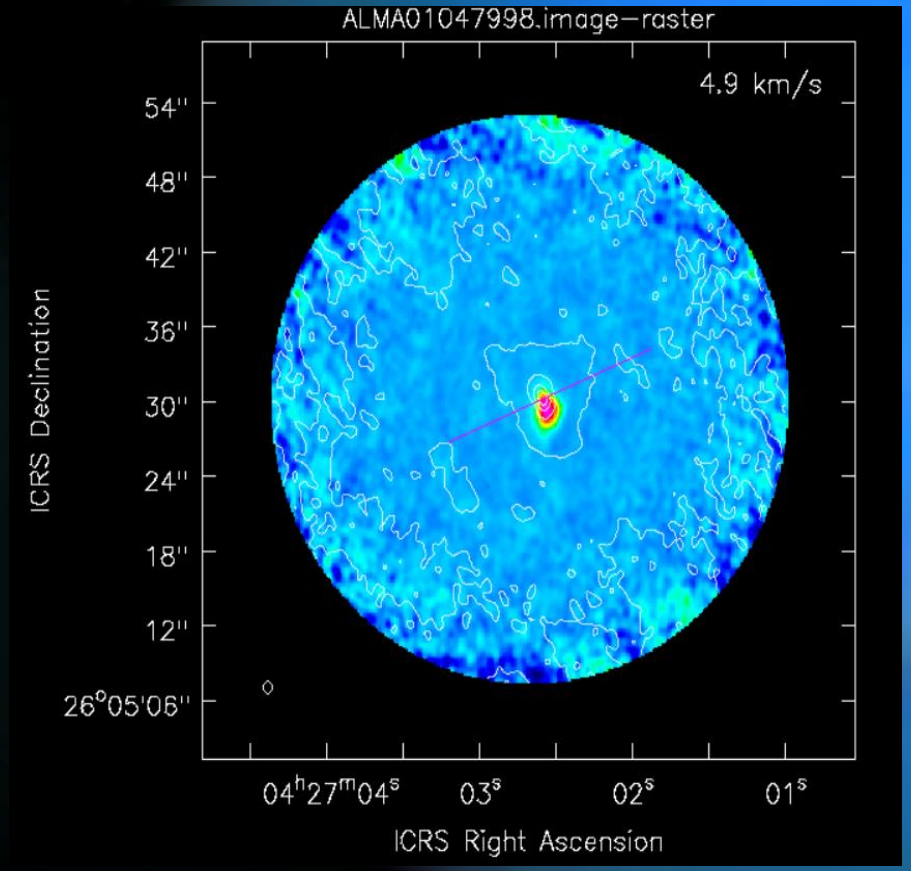
Pa=18.64

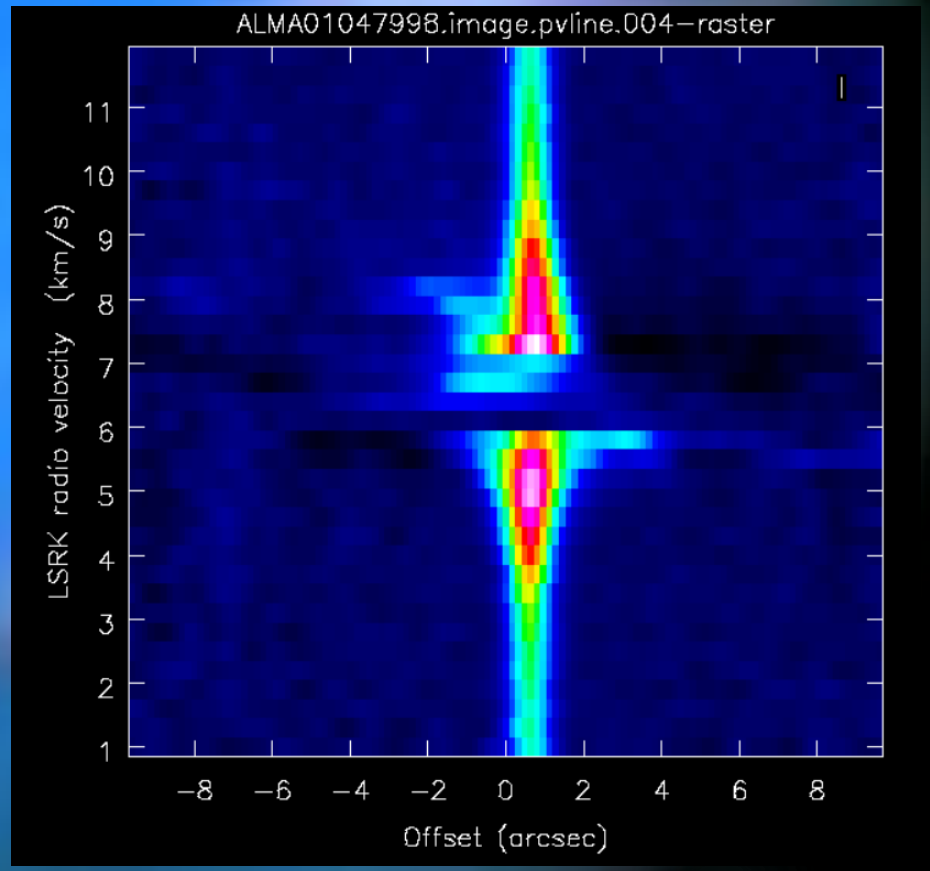




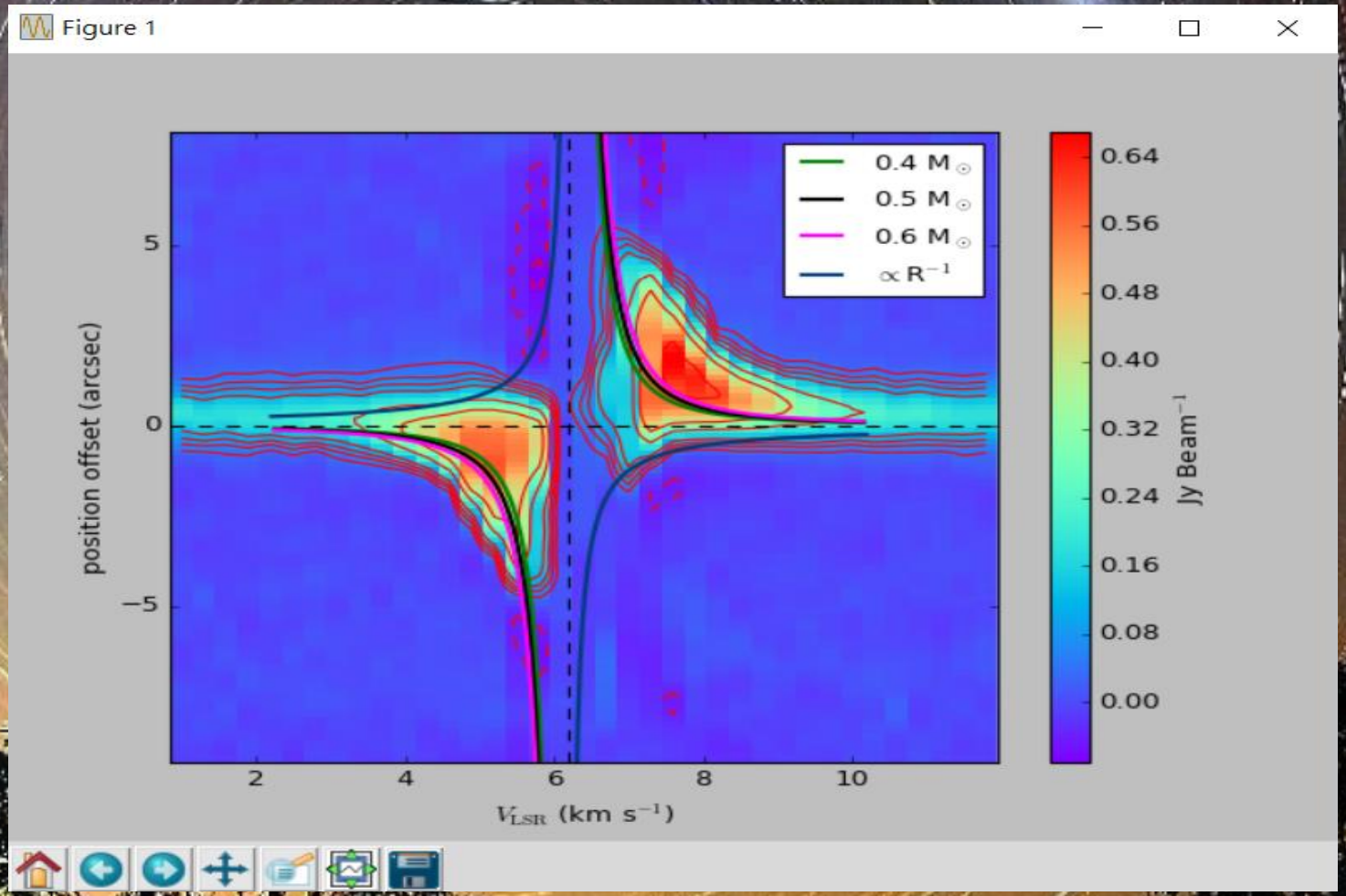
Pv diagram

Pa=-67





Keplerian curve



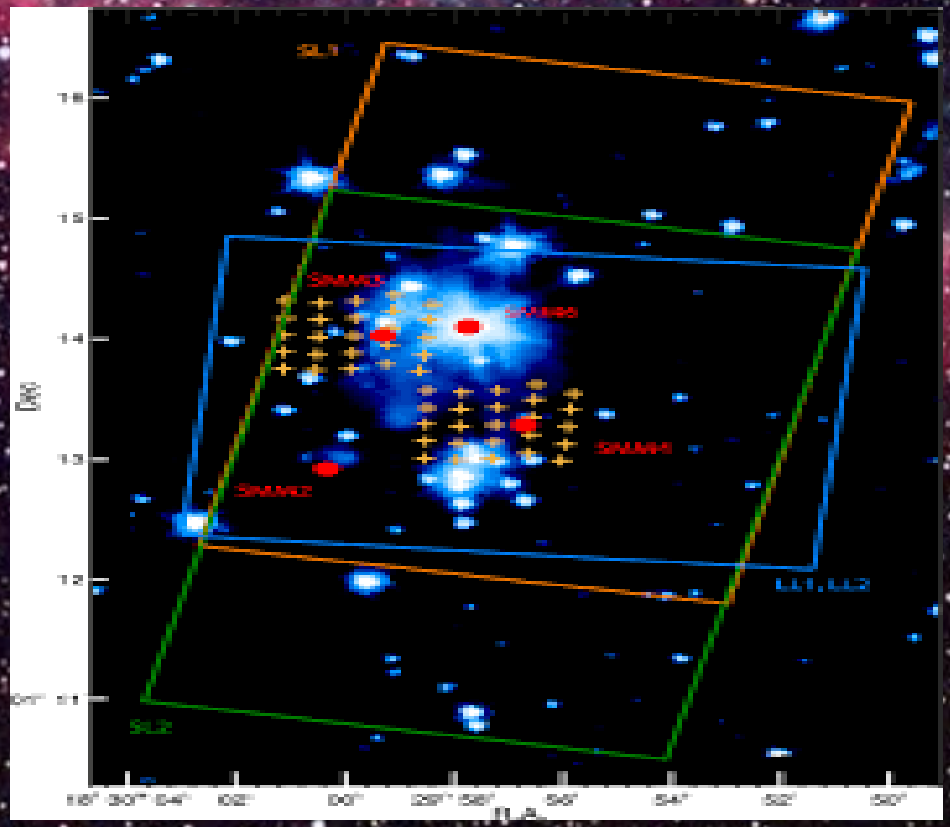
The mass of the disk

- I use column density to calculate the quantity of the molecular per cm^2 ,and use this to calculate the mass of the disk.

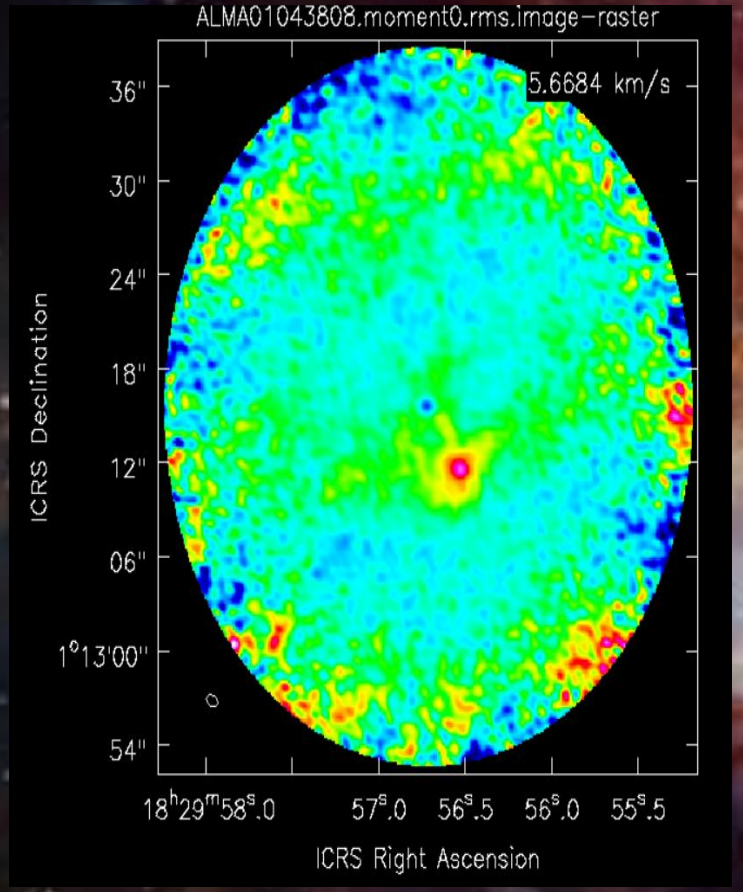
- Therefore I calculate the mass of the disk(DG TAU B) for 0.0541 solar mass.

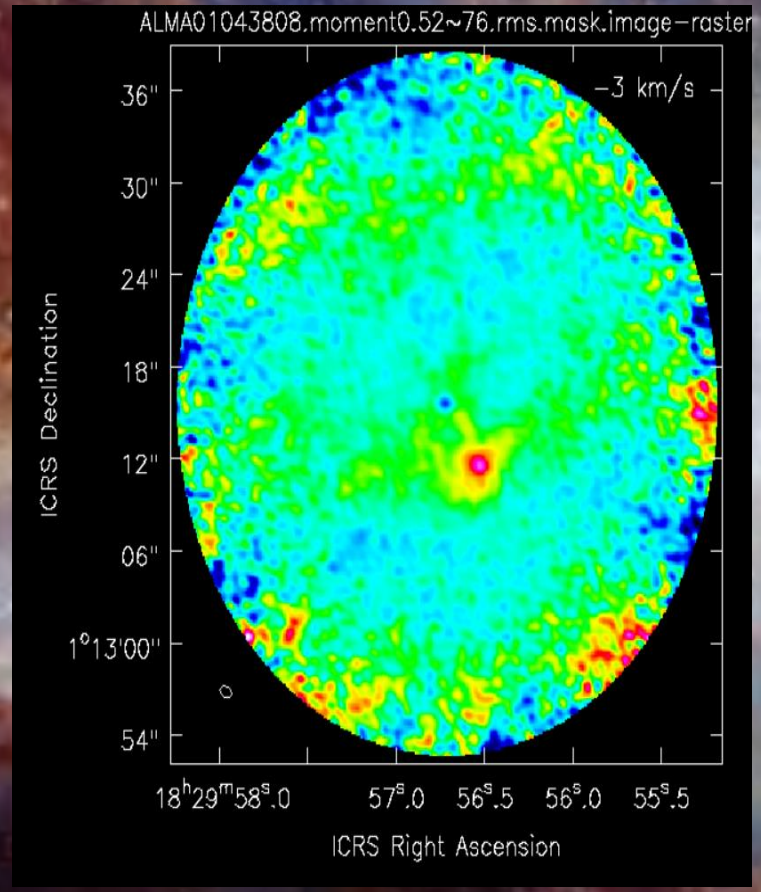
Example:serpens_smm4

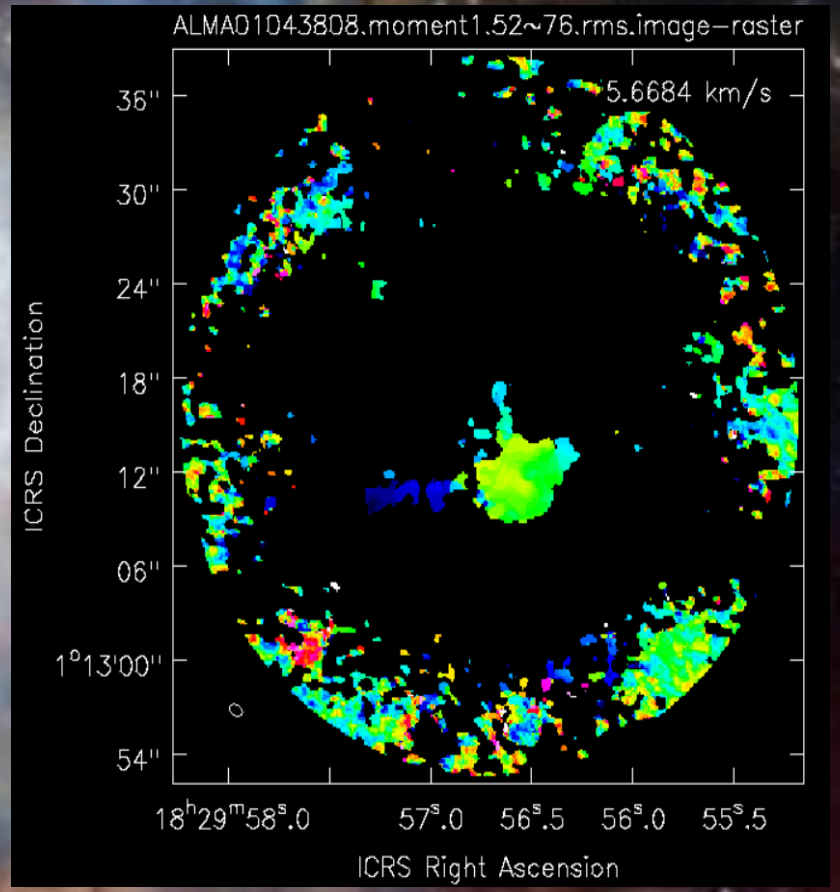
System: single protostar system
Center:18h29m56.7 +01d13m15
Class:0
Spectrum:C18O(2-1)



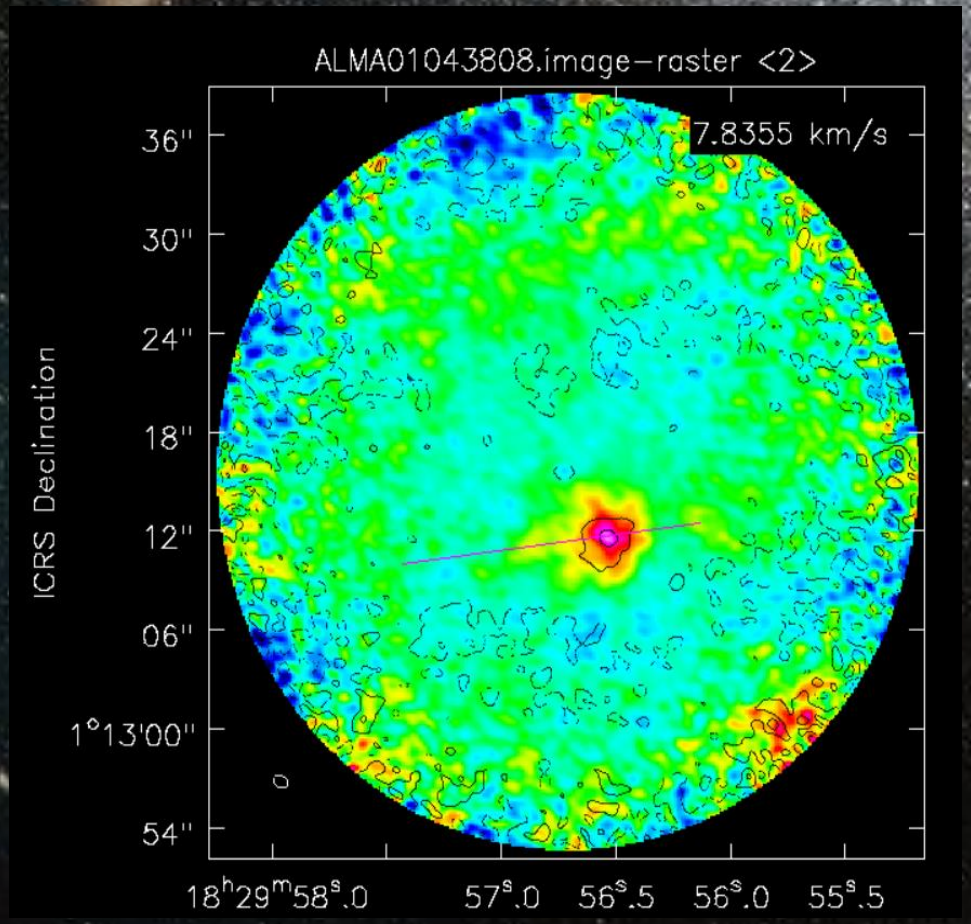
Moment map


ALMA01043808.moment0.rms.image-raster
5.6684 km/s
36"
30"
24"
18"
12"
06"
1°13'00"
54"
ICRS Declination
18h29m58s.0
57s.0
56s.5
56s.0
55s.5
ICRS Right Ascension

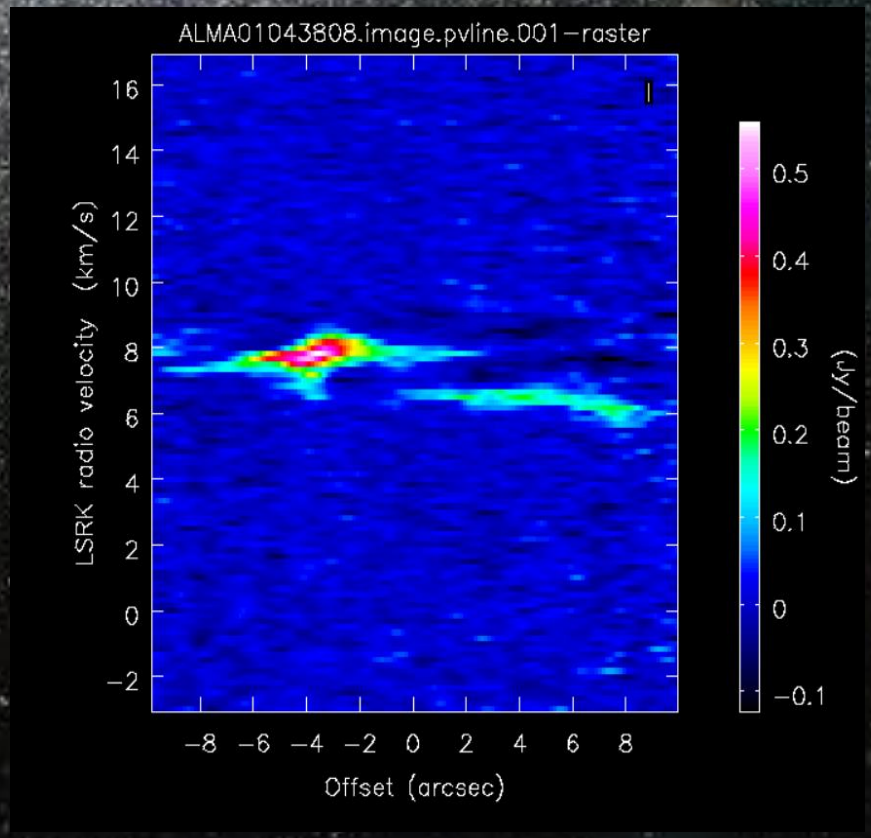

ALMA01043808.moment0.52~76.rms.mask.image-raster
-3 km/s
36"
30"
24"
18"
12"
06"
1°13'00"
54"
ICRS Declination
18h29m58s.0
57s.0
56s.5
56s.0
55s.5
ICRS Right Ascension


ALMA01043808.moment1.52~76.rms.image-raster
5.6684 km/s
36"
30"
24"
18"
12"
06"
1°13'00"
54"
ICRS Declination
18h29m58s.0
57s.0
56s.5
56s.0
55s.5
ICRS Right Ascension

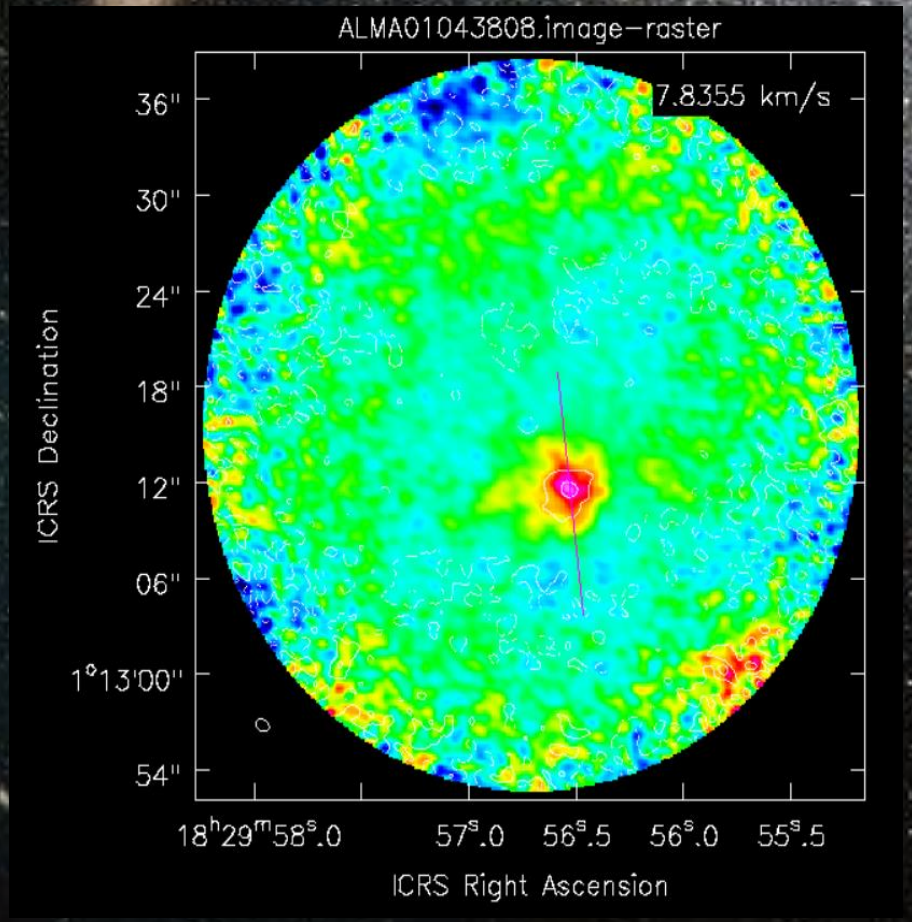
Pv diagram



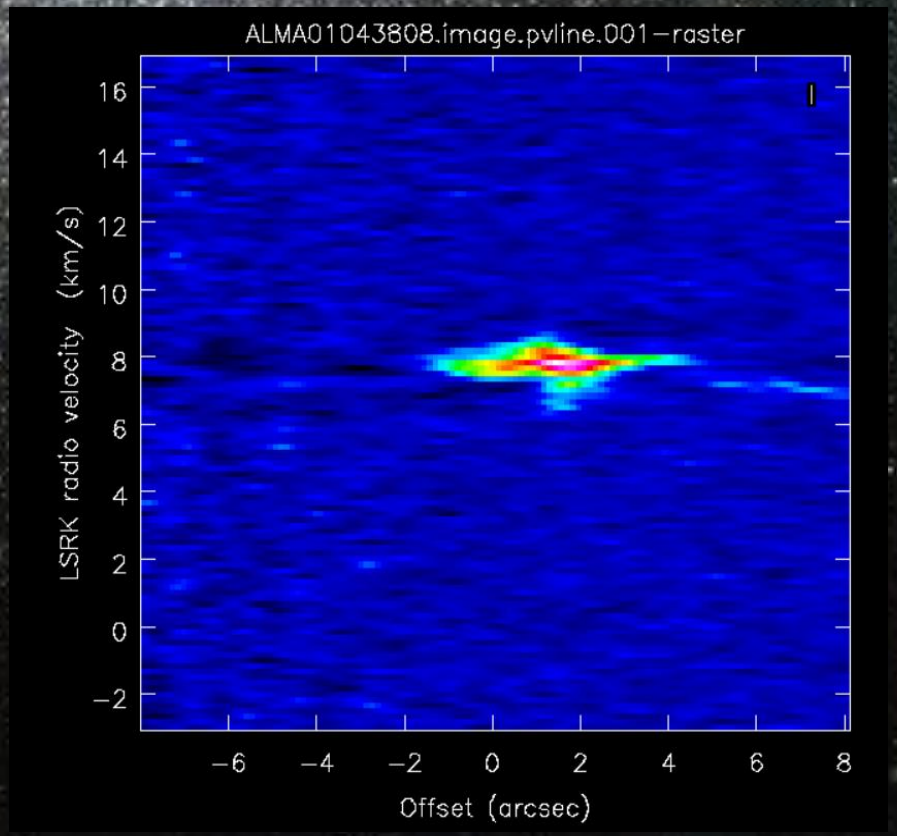
Pa=7



Pv diagram



Pa=98



Conclusion

source	Line	Keplerian disk	Mass of the disk
Lupus3 MMS (class 0)	C18O	△	×
serpens_smm4 (class 0)	C18O ,13CO	×	×
TMC1A (class 1)	C18O	√	0.019 solar mass
L1551NE (class 1)	C18O	×	0.046 solar mass
DG TAU B (class 1)	C18O	√	0.054 solar mass
L1448(class 0)	C18O,13CO	√	0.045 solar mass

reference

- https://inspirehep.net/record/1242093/plots
- http://science.howstuffworks.com/how-are-stars-formed.htm
- https://arxiv.org/pdf/1411.0173.pdf
- http://iopscience.iop.org/article/10.3847/1538-4357/aa6116/pdf
- http://iopscience.iop.org/article/10.3847/1538-4357/834/2/178/pdf

Thanks for listening