# The circumstellar disk of HD163296

Chia-Ming Chang

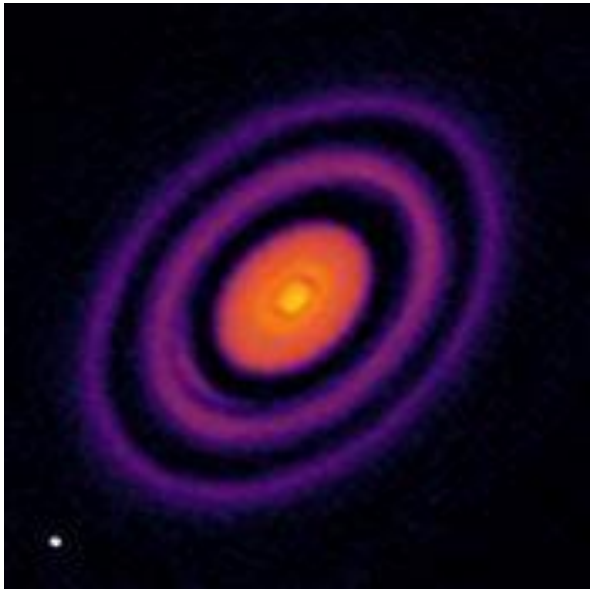
Supervisor: Prof. Shih-Ping Lai

Date: 2021/08/31

# Circumstellar Disk of HD163296

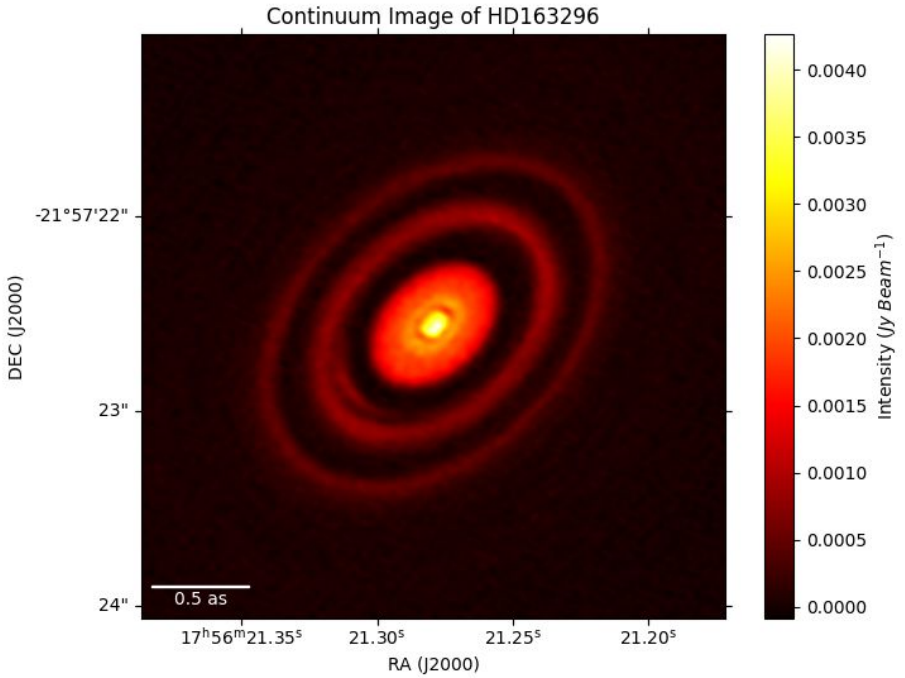
- Data from **DSHARP** (Disk Substructures at High Angular Resolution Project)
- 240 GHz (1.25mm) continuum & $^{12}CO$ (J=2-1) emission images (res~35mas)
- Lots of details could be used for researching the circumstellar disk

I will discuss its morphology and try to find some physical parameters in this representation.



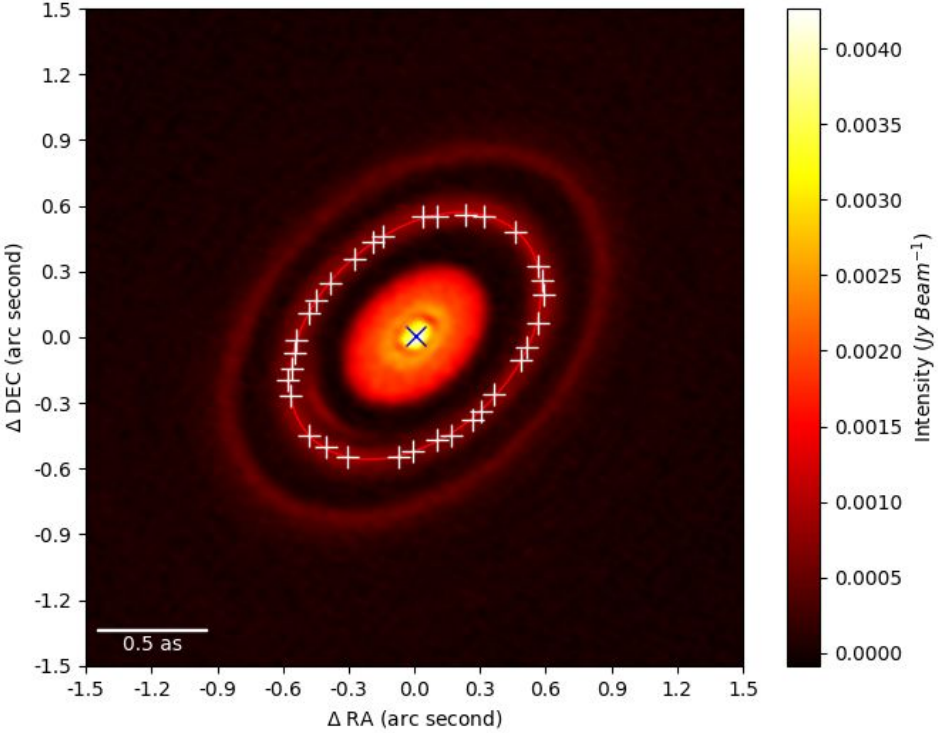
# Continuum Image of HD163296

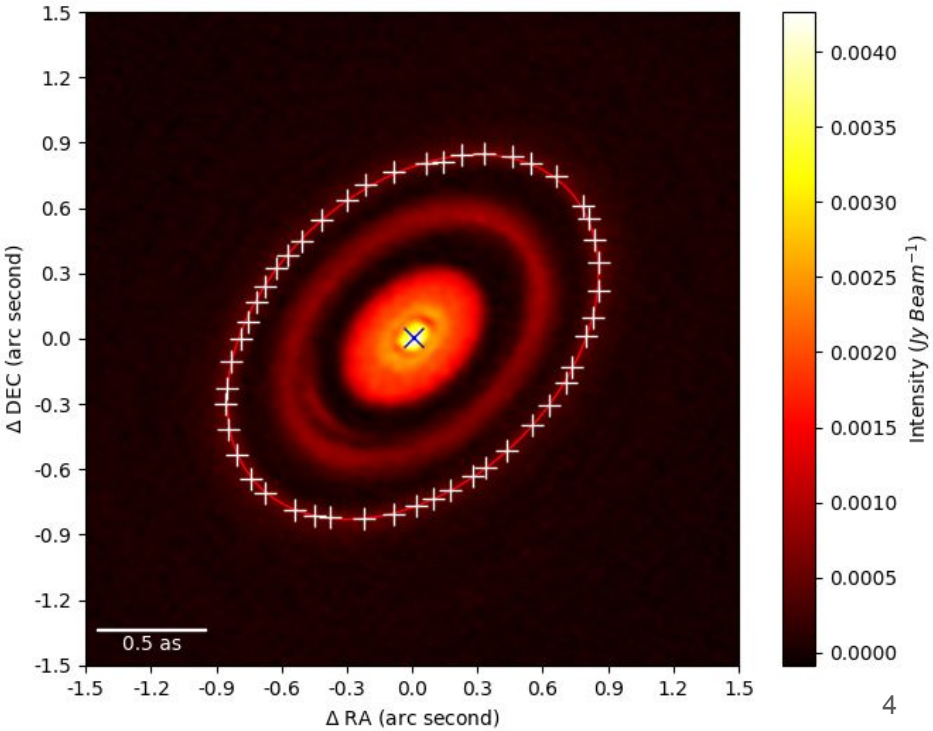
- The disk has rings and gaps
- Seems there is an instable area on the middle left part of the image



# Find the Inclination and PA from Disk Morphology

local maxima locations on the ring



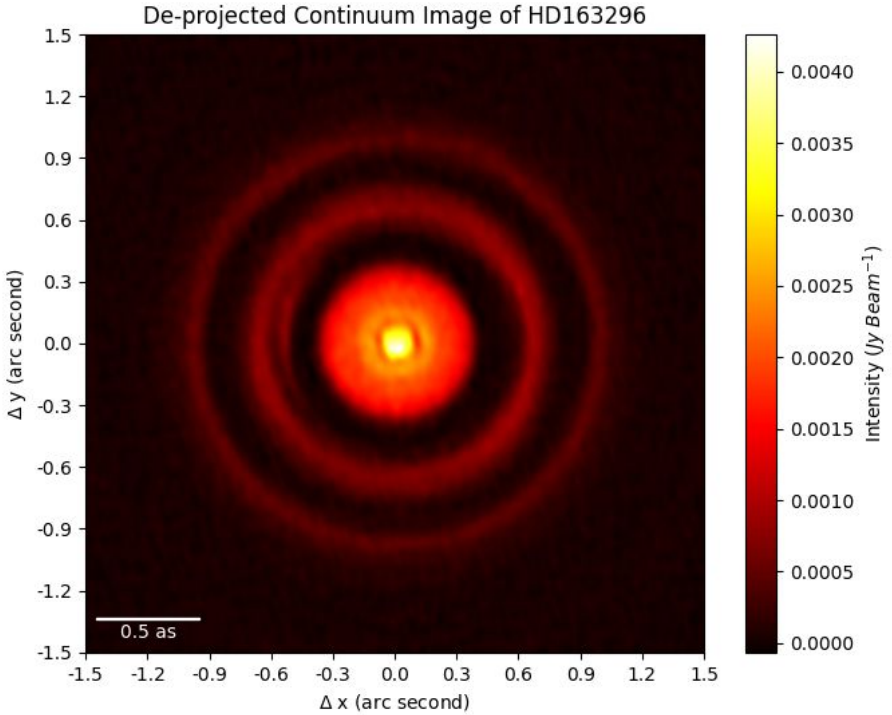
# Find the Inclination and PA from Disk Morphology

Fitting results from inner and outer ring

| | Inner ring | Outer ring |
|---|---|---|
| ΔRA, ΔDEC | 1.51±0.48 px, 1.93±0.46 px | 0.90±0.60 px, 2.49±0.60 px |
| **PA** | 43.50°±0.33° | 43.41°±0.27° |
| Major axis | 221.67±0.81 px | 327.99±0.86 px |
| Minor axis | 151.14±0.39 px | 226.21±0.52 px |
| **Inclination** | 47.01°±0.14° | 46.39°±0.11° |

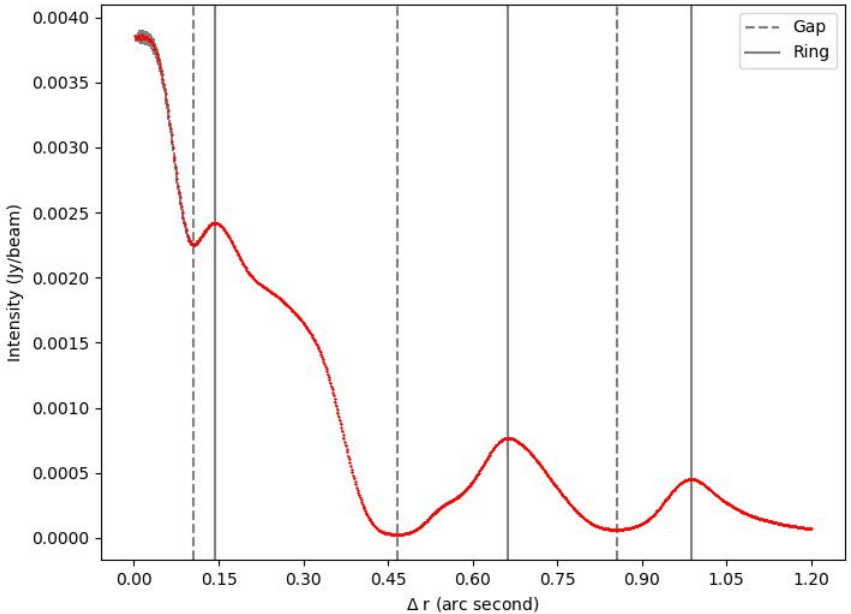
# De-projected Continuum Image

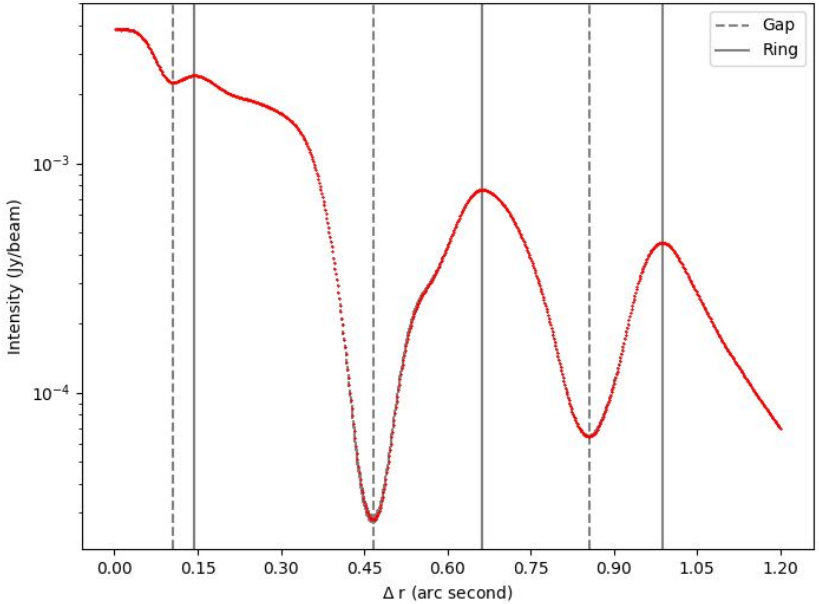
- Using the fitting results to deproject image for further analysis
- The missing pixels were filled by interpolation



# Radial Profile of Intensity of Continuum Image

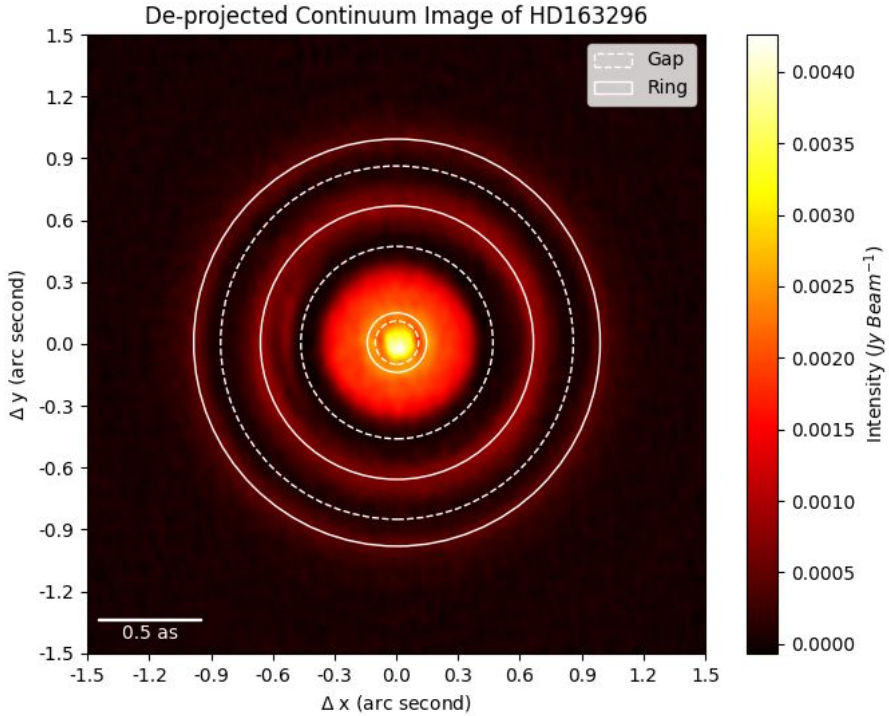
Determine rings and gaps from intensity profile



# Radial Profile of Intensity of Continuum Image

| Structure | Radius (AU) |
|---|---|
| G11 | 10.60 |
| R15 | 14.54 |
| G47 | 47.09 |
| R67 | 66.93 |
| G86 | 86.46 |
| R100 | 99.64 |




R→ring, G→gap

# CO Image of HD163296

- Sequence of images consist of CO intensity at different radial velocities (freq.)
- Through data processing, we can get the **distribution**, **velocity** and **dispersion** of velocity of CO. It helps us know the physical properties of the gas.

Moment 0
Integrated line intensity

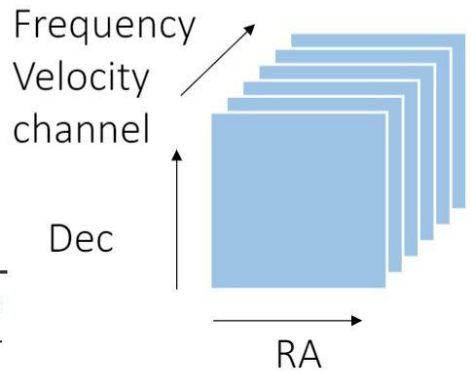
$$M_0 = \int I_v dv$$

Moment 1
Mean velocity

$$M_1 = \frac{\int I_v \cdot v dv}{M_0}$$

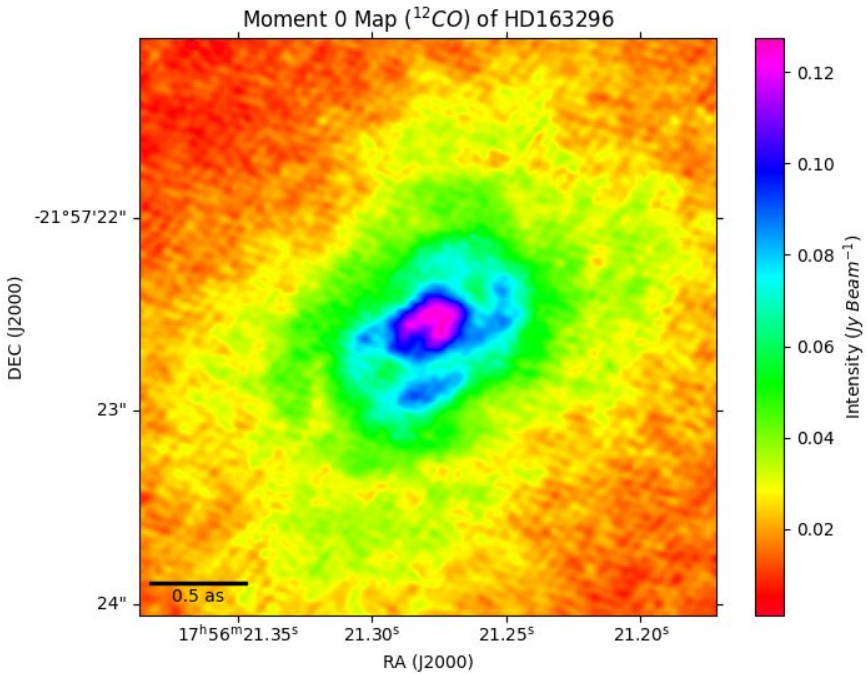
Moment 2
Velocity dispersion

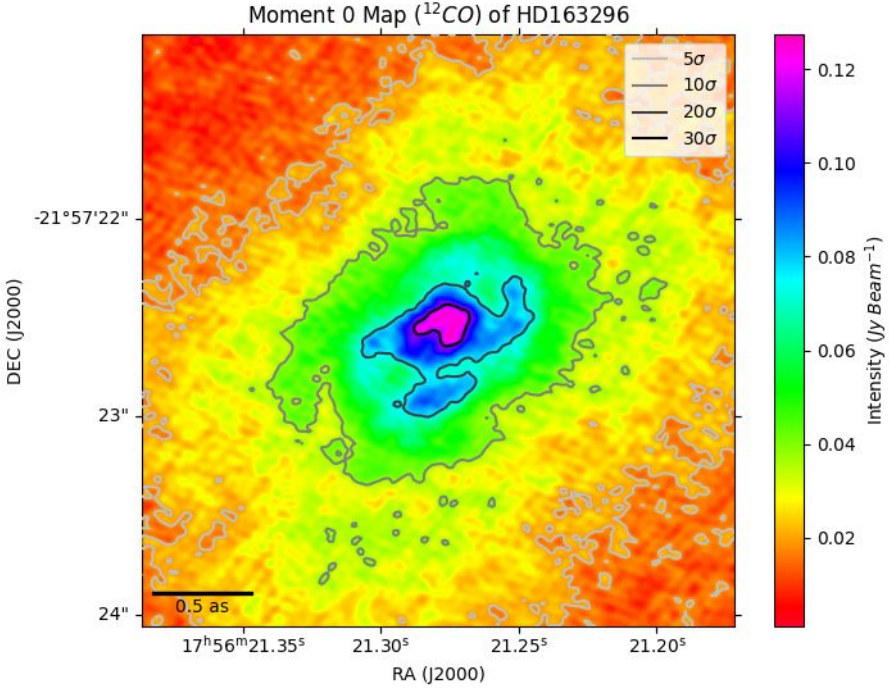
$$M_2 = \sqrt{\frac{\int I_v \cdot (v - M_1)^2 dv}{M_0}}$$



# Moment 0 Map of HD163296

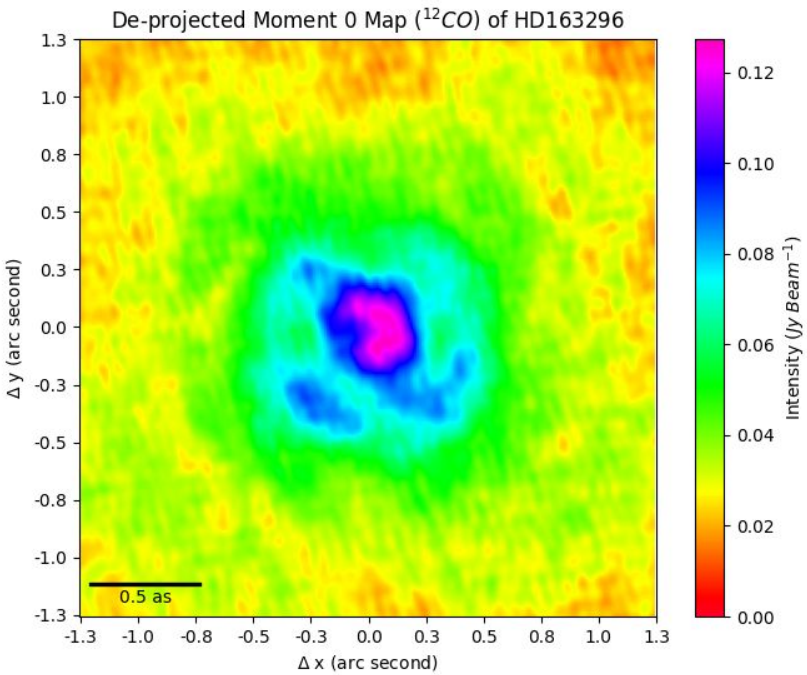
Reveal some structures in moment 0 map

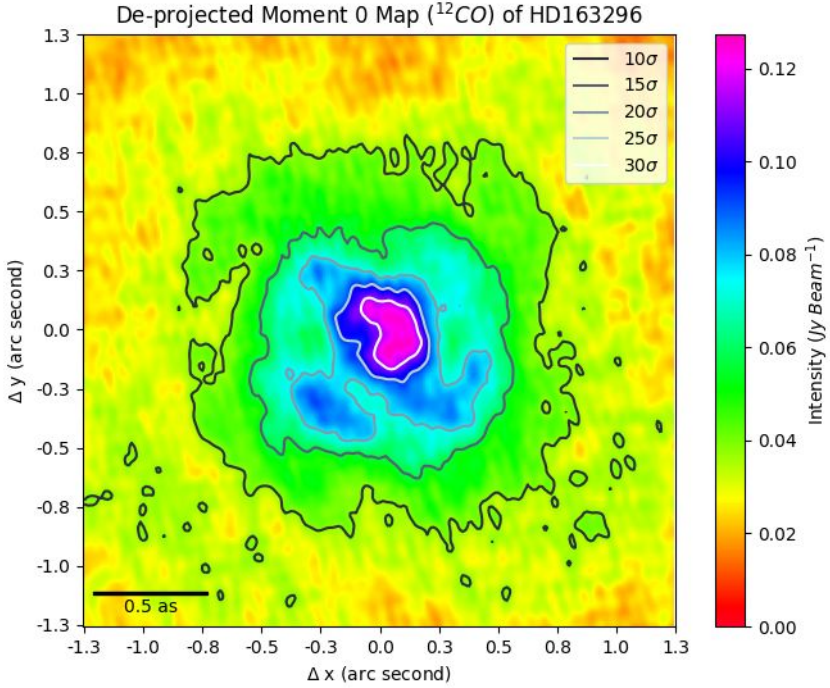


# De-projected Moment 0 Map of HD163296

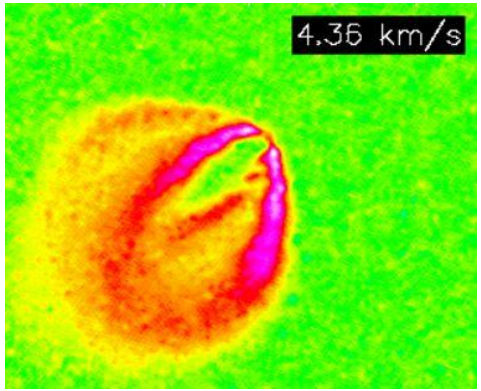
Using the fitting parametes from previous part to deproject images



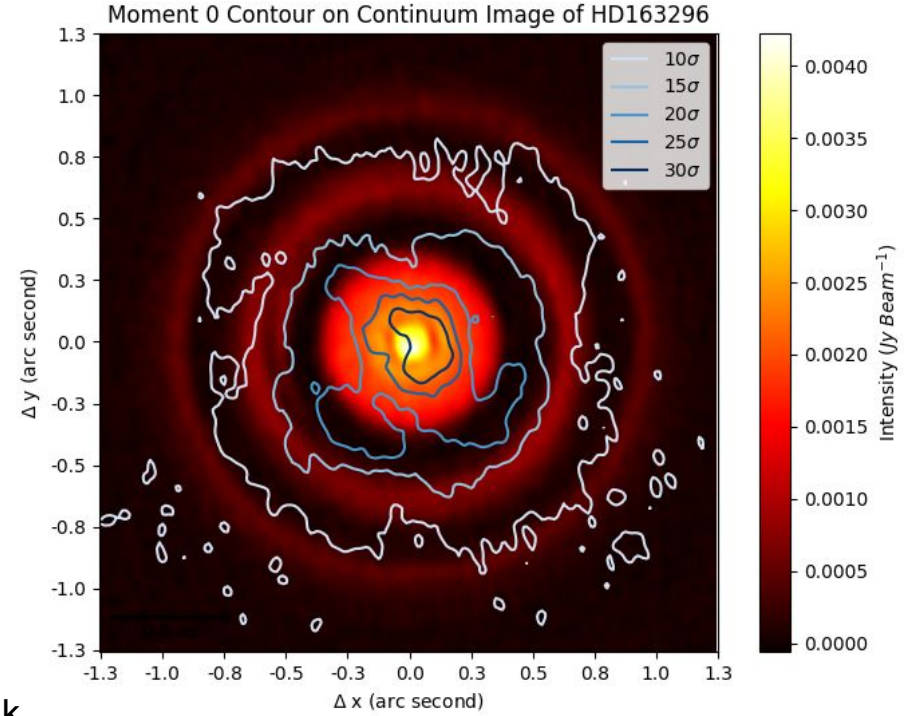



# De-projected Continuum Image with CO Moment 0 Contour

- The distribution of CO is not symmetric on the disk
- The projection may be inaccurate since it is not a “thin” disk.

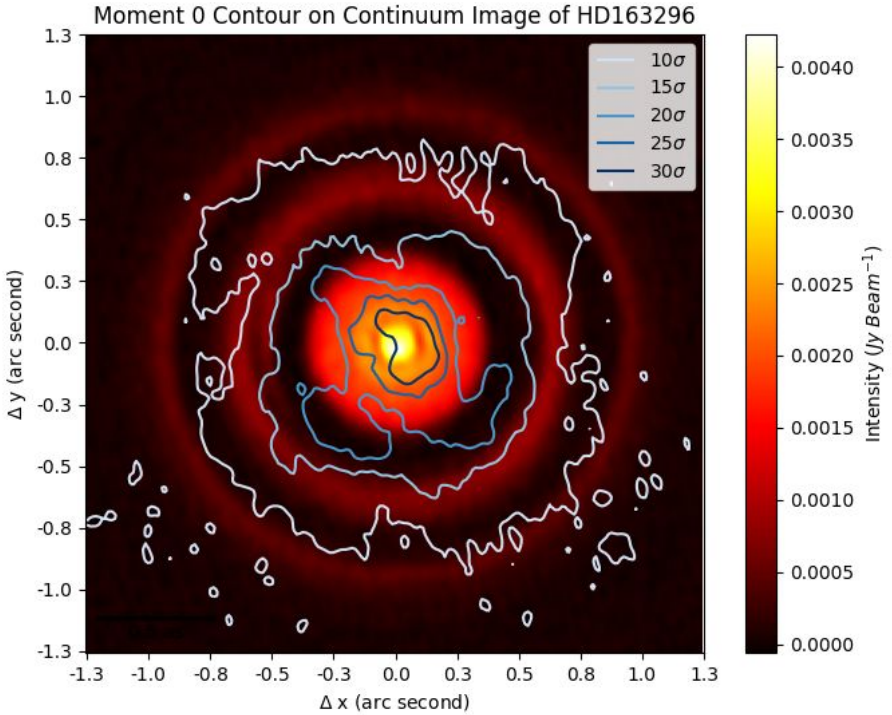



Evidence of thick disk



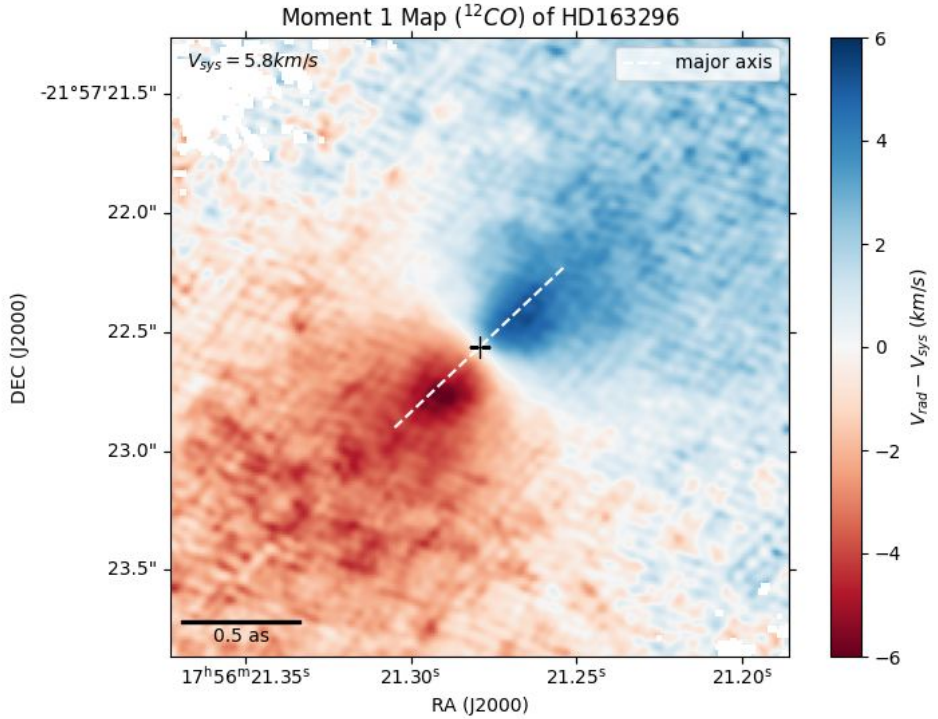
# De-projected Continuum Image with CO Moment 0 Contour

- The distribution of CO is not symmetric on the disk
- The projection may be inaccurate since it is not a “thin” disk.



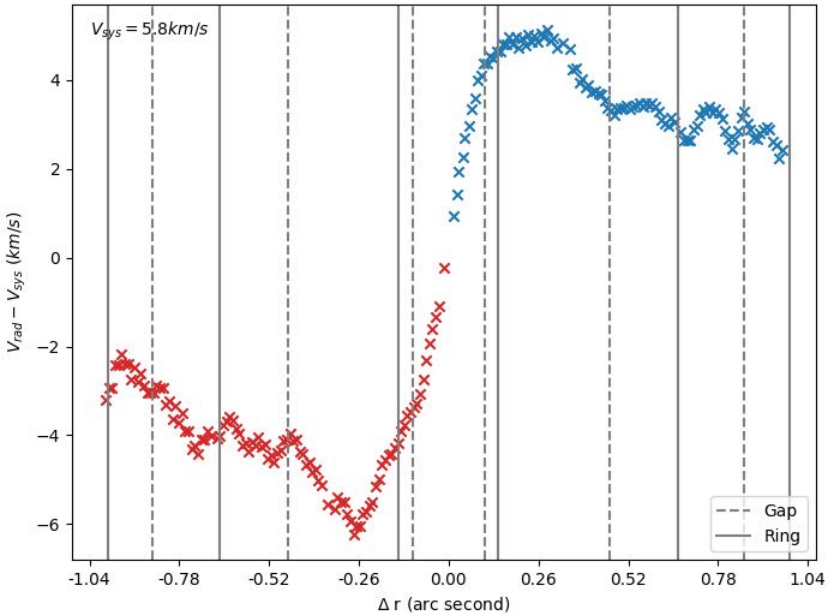
# Moment 1 Map of HD163296

- By Doppler effect, we can measure the radial velocity of CO
- The system velocity of HD163296 is 5.8±0.2 km/s, Qi et al. (2011)

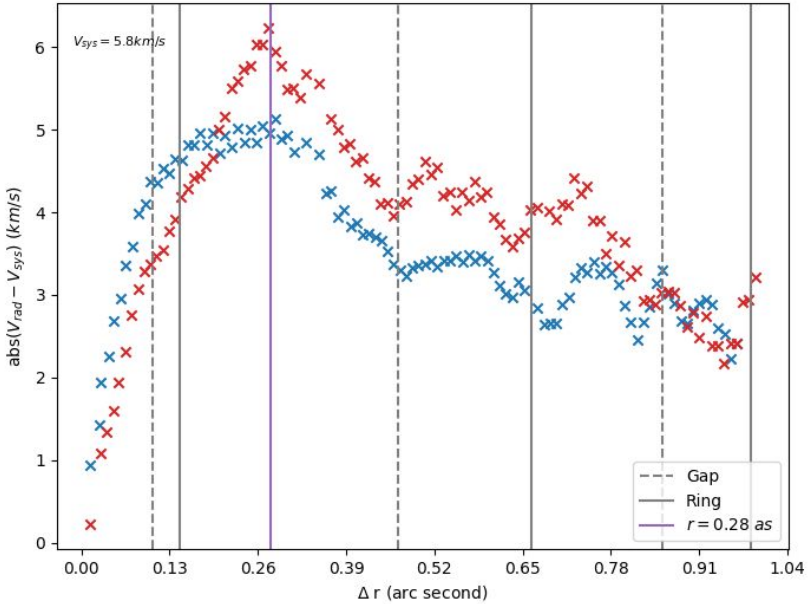


# Velocity Profile of HD163296

Sampling along the major axis of the disk



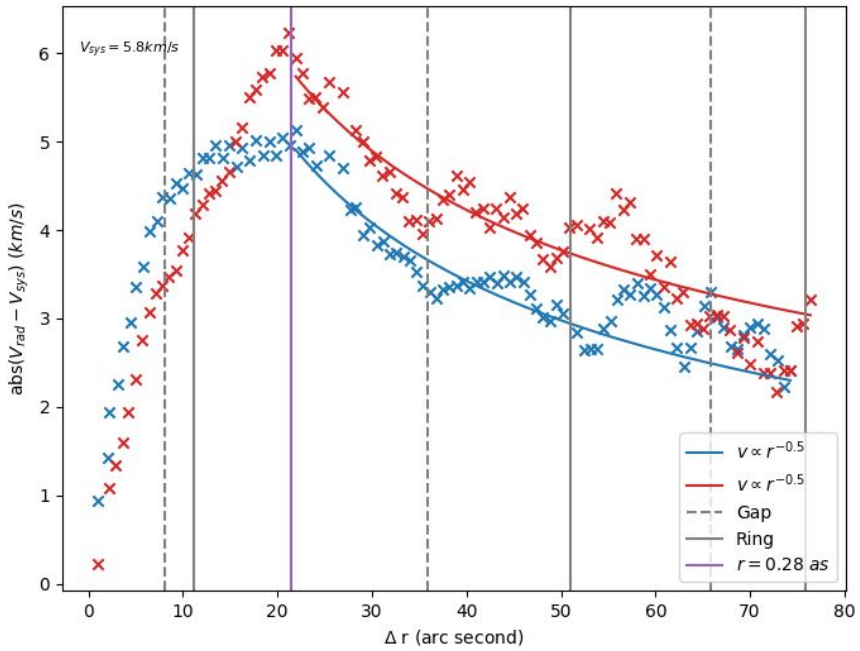

r < 0.28 arcsec is non-keplerian disk



# Fitting the Velocity Profile

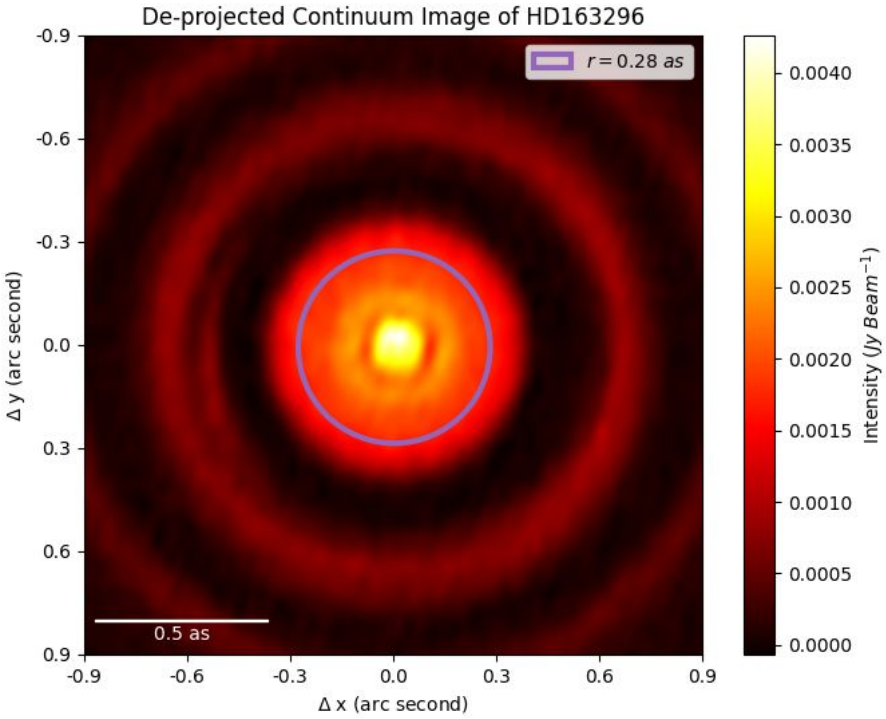
- If the disk is stable, it will obey the kepler's law of motion, the radial velocity should follow below equation.
- It seems the disk is non-keplerian when radius < 0.28 arcsec (28AU)

$$v(r) = \sqrt{\frac{GM_*}{r}}$$

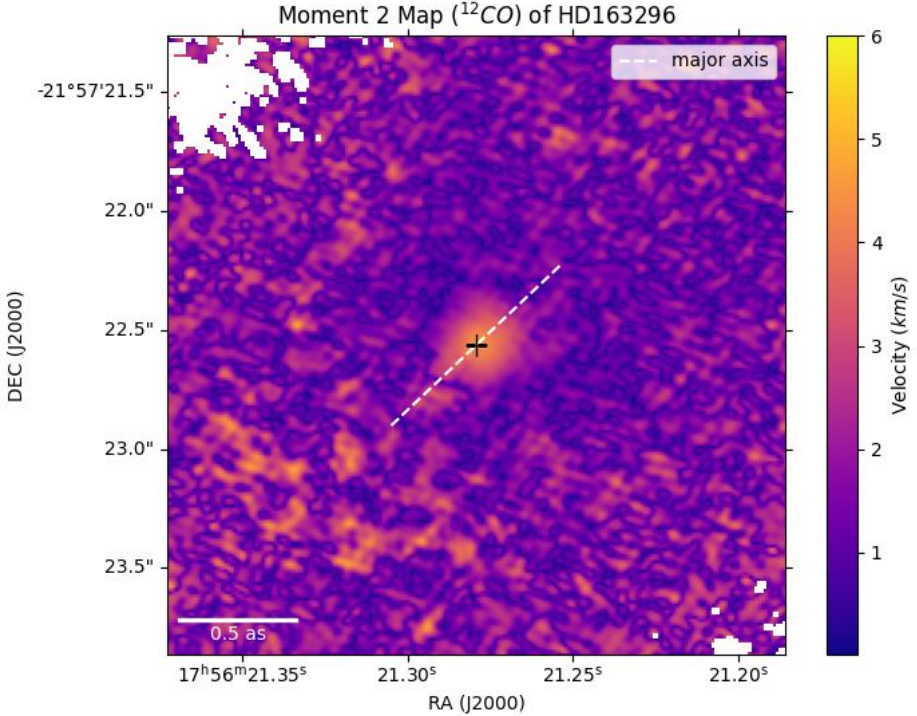



Infall

# Velocity Profile of HD163296

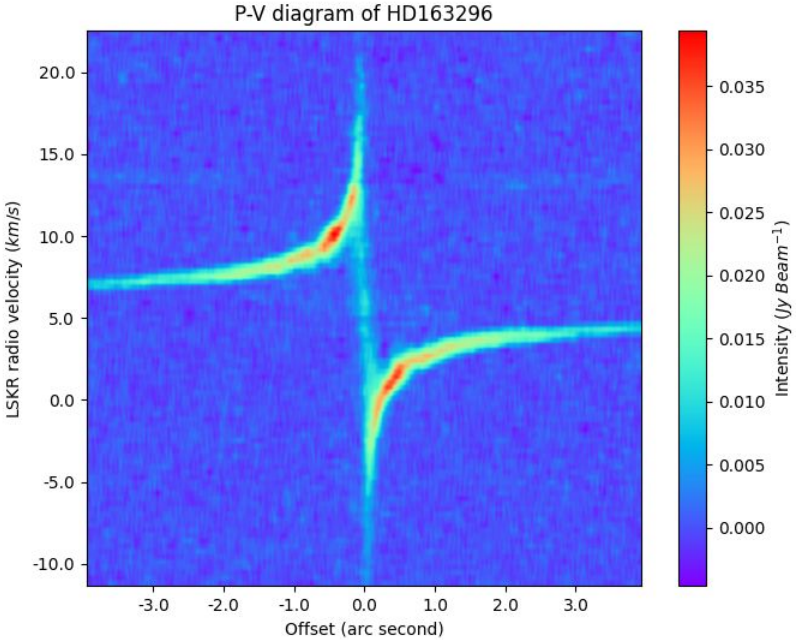


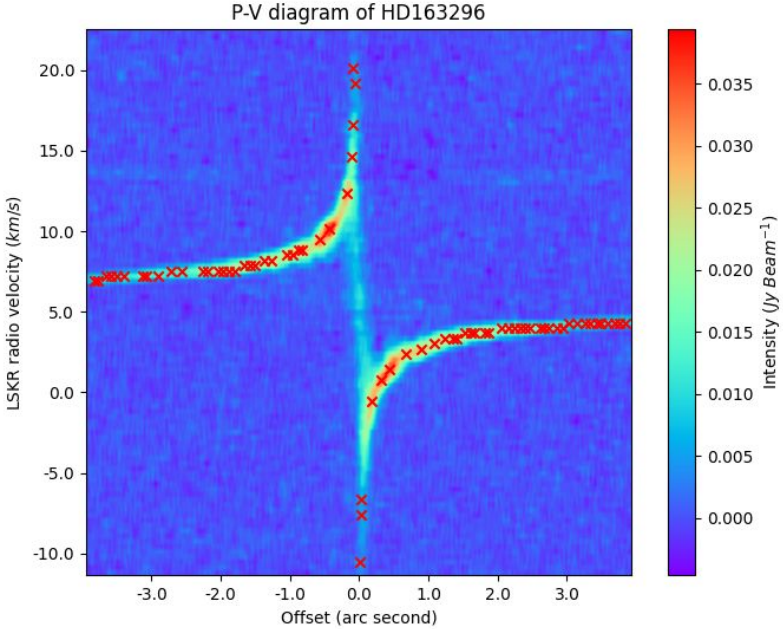
# Moment 2 Map of HD163296



# P-V Diagram of HD163296

- Position-Velocity diagram

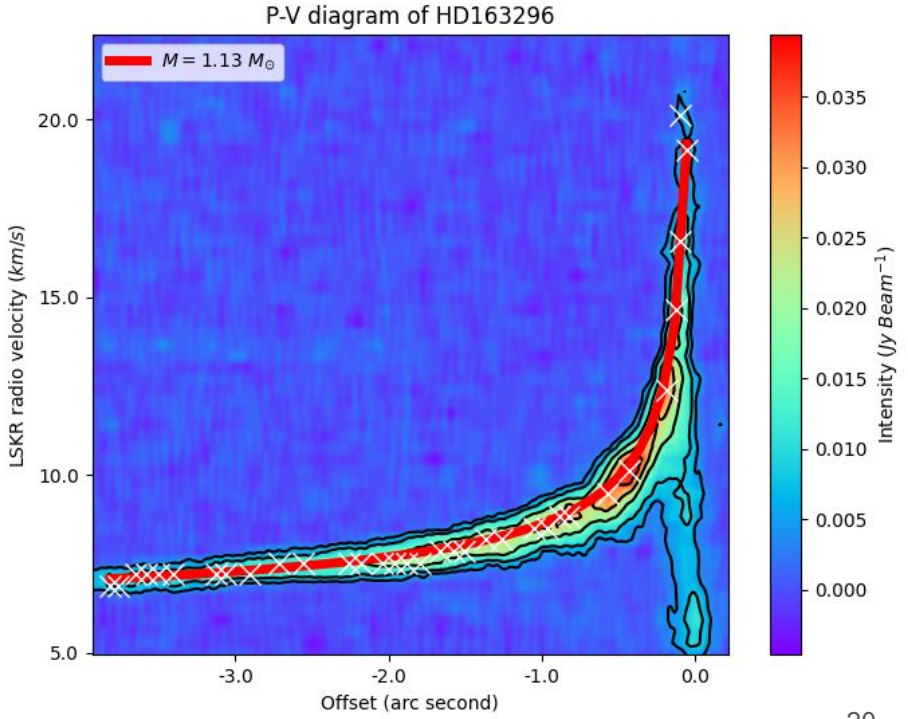


# Fitting the P-V Diagram

- We can  calculate the central mass of the disk by regarding it as a keplerian disk

- The predicted mass M is 1.13±0.07 M ⊙, after considering the projection effect of inclination, the actual central mass will be **M =  2.38±0.15 M ⊙**.



# Conclusion

- Through the high resolution images by ALMA, we can easily determine the physical properties of the circumstellar disk.
- We can see the instable areas on the disk of HD163296, it may reveal us more about the formation of the planetary system with further research.
- There are many knowledges involved in which we can learn from it during the data processing.

# References


1. P.N. Diep, The protoplanetary disc of HD 163296 as observed by ALMA
2. Andrea Isella, A High-definition Study of the HD 163296 Planet-forming Disk
3. M. T. Carney, Upper limits on CH3OH in the HD 163296 protoplanetary disk