AS209;

Image processing & Physical properties of circumstellar disk

Group 2

Members

1

Dr. RYO ARAN

2

KIM MINSU

3

KIM CHULWHAN

4

JEONG JAEHONG

01

IMAGE CLEANING

Explore effects on outcome using different weights

02

DISK MASS CALC.

Calculate disk mass using continuum data

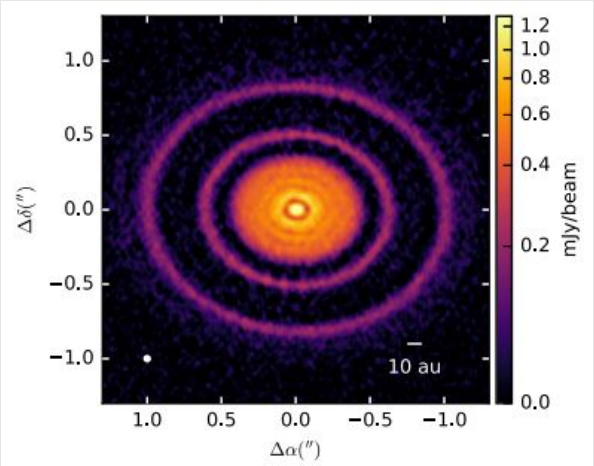
03

MOMENTS MAP and CENTRAL STAR MASS CALC.

Create moment maps and
Calculate mass of central star using both continuum and CO line data

Target

Fig. 1., Guzman et al. 2018



AS209

T Tauri w/ disk

Distance	: 121 pc	(Gaia Colab. et al. 2018)
Mass (star)	: 0.9 Solar	(Andrews et al. 2018)
Age	: 1.6 Myr	(Andrews et al. 2018)

Data

Continuum (Traces thermal radiation from dust)

Central Frequency	: 230-245 MHz
Total Bandwidth	: 90-200 MHz
#Chans	: 4-16
Spw	: 0-24
Max Baseline	: ~11.5 km

12CO(J=2-1) (Traces gas (molecular))

Total Bandwidth	: 16 MHz (21 km/s)
Channel Width	: 269 kHz (0.358 km/s)
#Chans	: 60
Spw	: 0-3
Max Baseline	: ~11.5 km

01.

IMAGE CLEANING

We explore effects on outcome using different weights

WEIGHTING METHODS

Natural

$$w_i = \omega_i = \frac{1}{\sigma_k^2}$$

PRO: Higher signal
CON: Worse resolution

Robust

Intermediate of Natural and Uniform

Uniform

$$w_i = \frac{\omega_i}{W_k}.$$

PRO: Better resolution
CON: Poor signal

IMAGE CLEANING: RESULTS (Continuum)

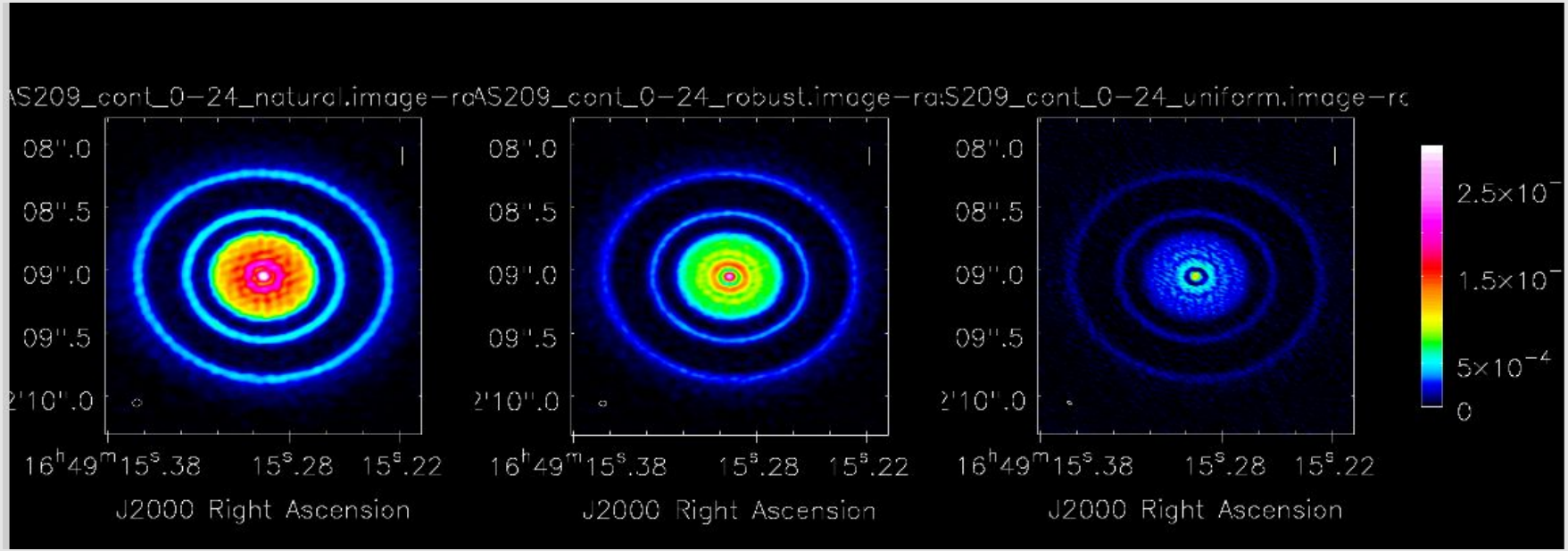


IMAGE CLEANING: RESULTS (Continuum)

	RestoringBeam Major	RestoringBeam minor	Noise level	Total flux (within 5sigma)
NATURAL	0.073”	0.051”	10 μJy	0.26 Jy
ROBUST	0.058”	0.039”	10 μJy	0.26 Jy
UNIFORM	0.037”	0.020”	30 μJy	0.22 Jy

IMAGE CLEANING: RESULTS (CO line)

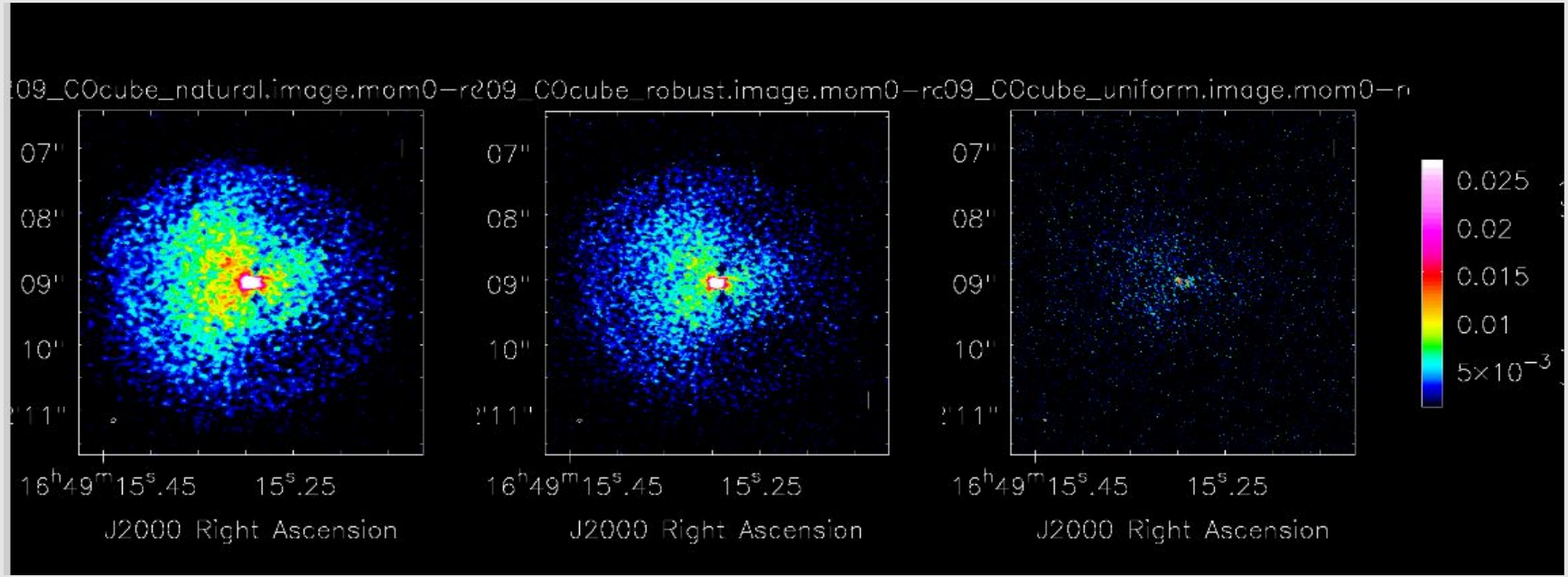


IMAGE CLEANING: RESULTS (CO line)

	RestoredBeam Major	RestoredBeam minor	Noise level	Integrated Flux
NATURAL	0.082	0.058	900 μJy	9.5 Jy km/s
ROBUST	0.068	0.048	950 μJy	8.5 Jy km/s
UNIFORM	0.045	0.030	1700 μJy	3.3 Jy km/s

02.

DISK MASS CALCULATION

We evaluate disk mass using dust continuum data

How to calculate disk mass?

$$M_{\rm disk} = 0.06\, M_\odot \frac{F_\lambda}{1\ {\rm Jy}} \left(\frac{d}{100\ {\rm pc}}\right)^2 \frac{50\ {\rm K}}{\langle T \rangle} \frac{0.01\ {\rm cm}^2\ {\rm g}^{-1}}{\kappa_{1.3\ {\rm mm}}}, \quad (6)$$

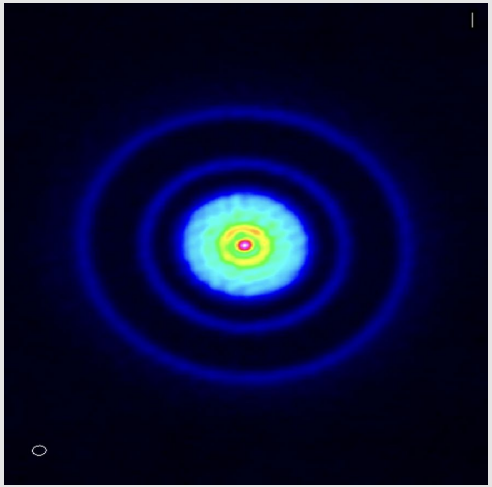
flux

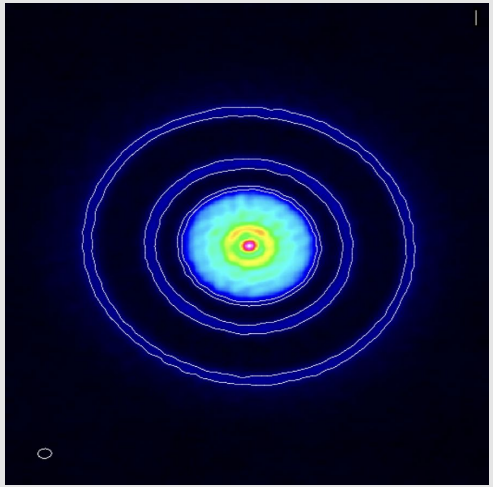
(Thi et al.(2001))

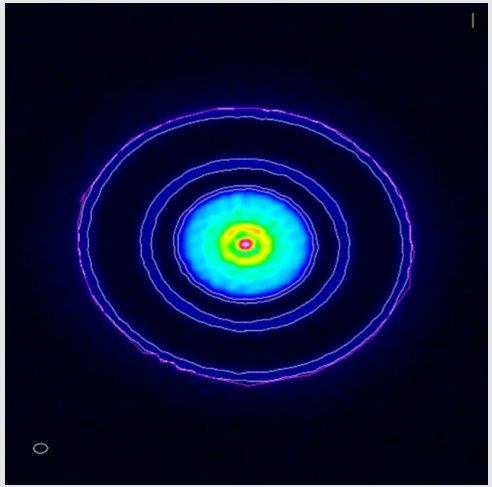
‹T› ≈ 15K
(Guzman et al.(2018))

d ≈ 121 pc
(Guzman et al.(2018))

κ ≈ 0.01 cm^2/g
(Thi et al.(2001))







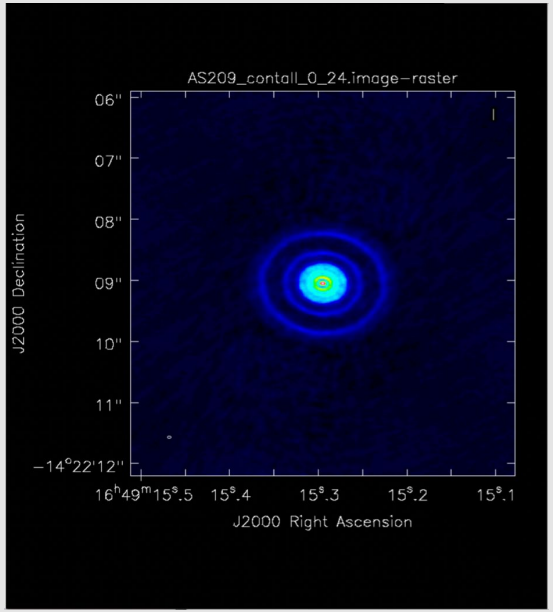
Disk Mass

(with three weighting methods)

	Flux Density (within 5 sigma)	Disk Mass ($M_\odot$)	Disk Mass (M_J)
Natural	0.26Jy	0.076	80
Robust	0.26Jy	0.076	80
Uniform	0.22Jy	0.064	67

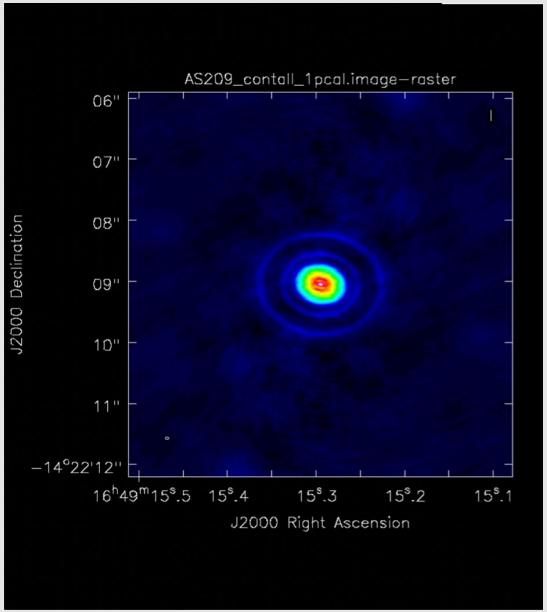
Something wrong with my method?

< Not Self-Calibrated >



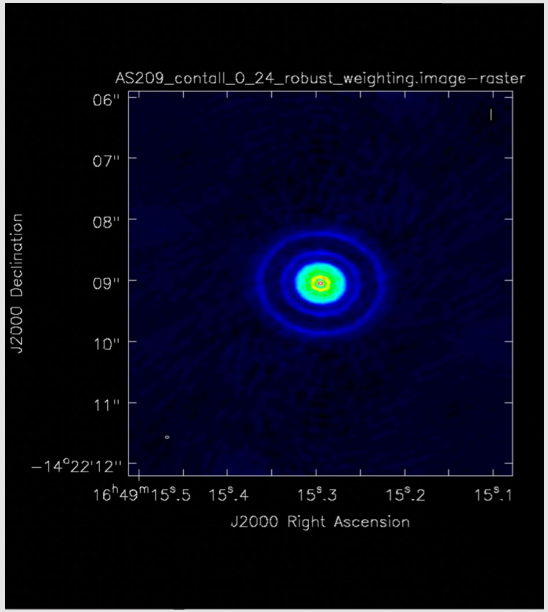
Disk mass: 0.160 $M_\odot$

< Self-Calibrated >



Disk mass: 0.162 $M_\odot$

< Increased Threshold & Not Self-Calibrated >

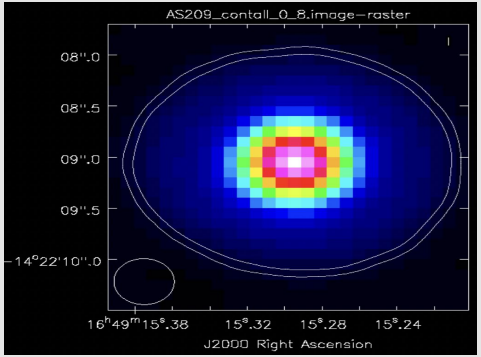


Disk mass: 0.157 $M_\odot$

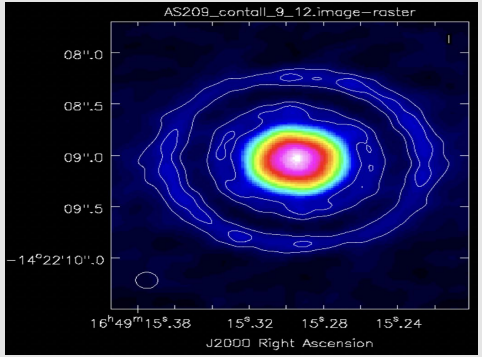
-> some systematic error?

Disk Mass (with different resolutions)

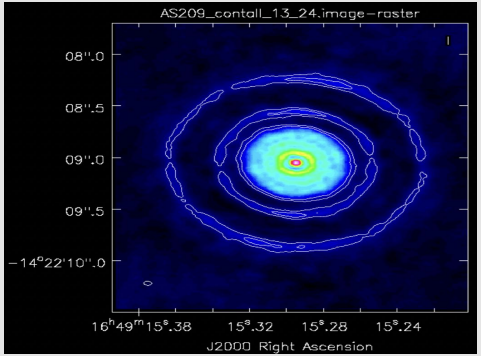
<0.47”>



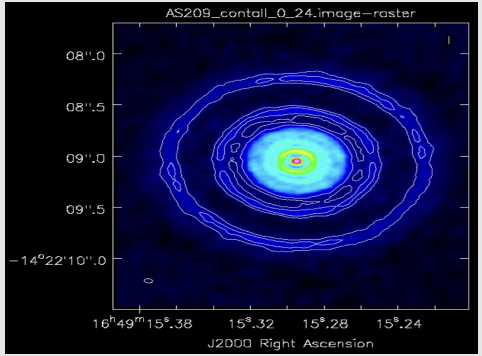
<0.11”>



<0.03”>



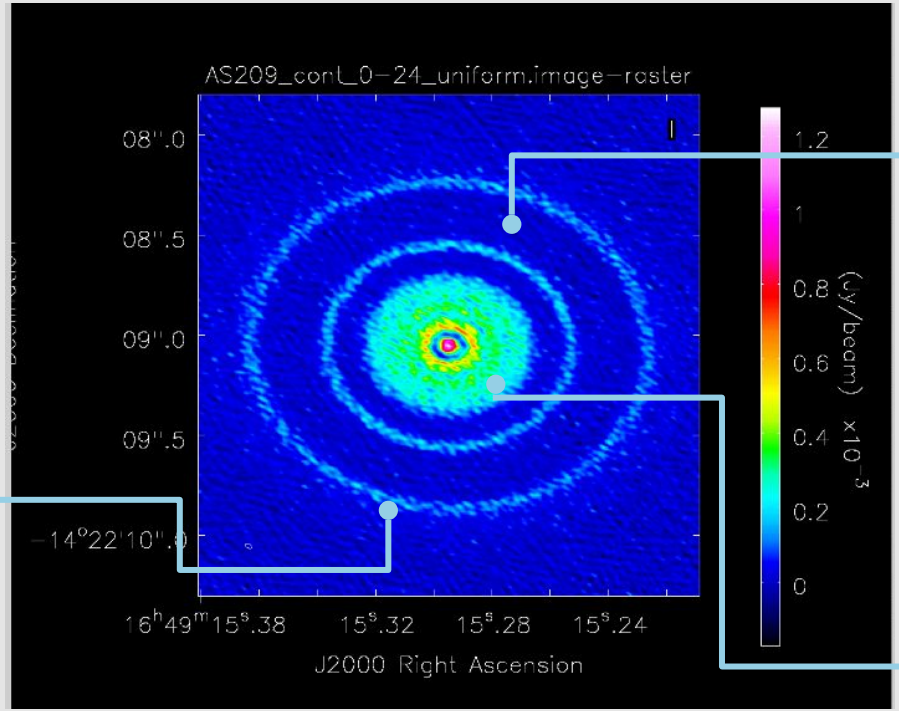
<combined”>



	Flux Density (Jy)	Disk Mass ($M_\odot$)
0.47”	0.24	0.070
0.11”	0.24	0.070
0.03”	0.25	0.073
combined	0.26	0.076

Disk (Sub)Structure

- Where does a planet form? (rings or gaps)
- Planet mass?

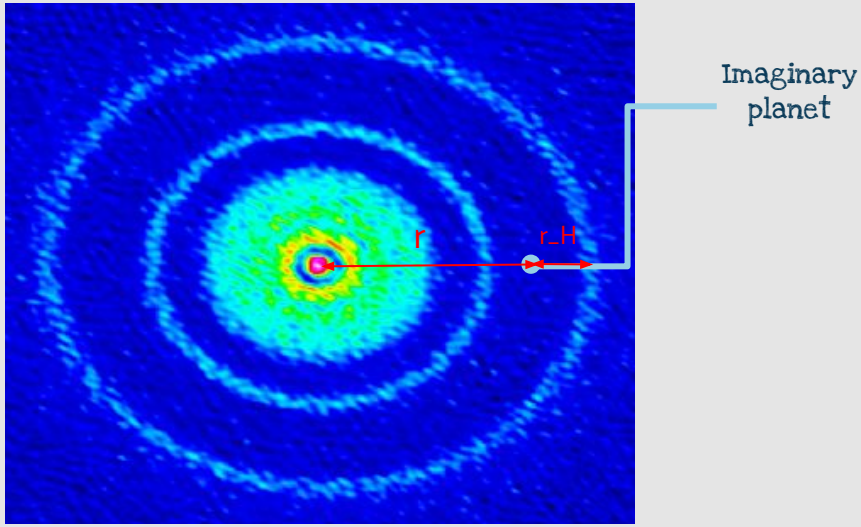


Gap

Ring

More compact structures

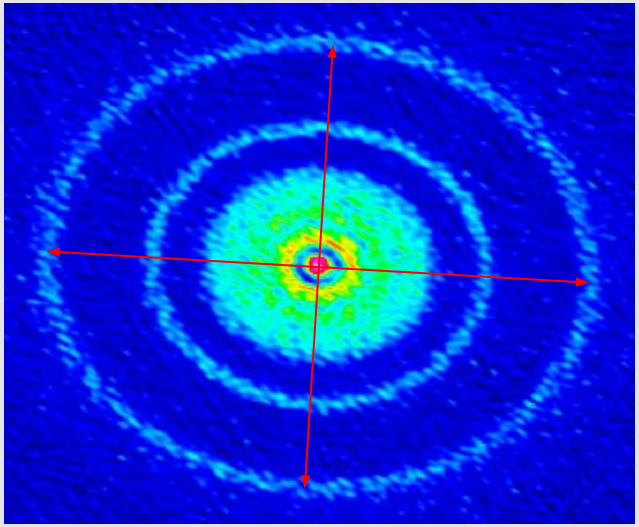
Planet mass + Disk inclination



Hill Sphere (Sphere of influence)

$$\frac{r_{\mathrm{H}}}{r} \approx \sqrt[3]{\frac{m}{3M}}.$$

https://en.wikipedia.org/wiki/Hill_sphere



Axis ratio = 0.81 = cos i

∴ i = 36 degree

03.

MOMENT MAPS and CENTRAL STAR MASS CALCULATION

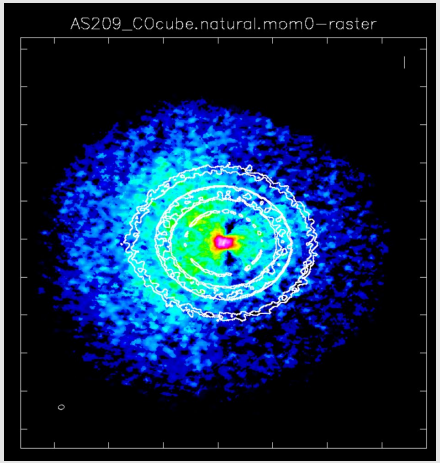
We create moments map and evaluate mass of central star using both continuum and CO line data

MOMENT MAPS

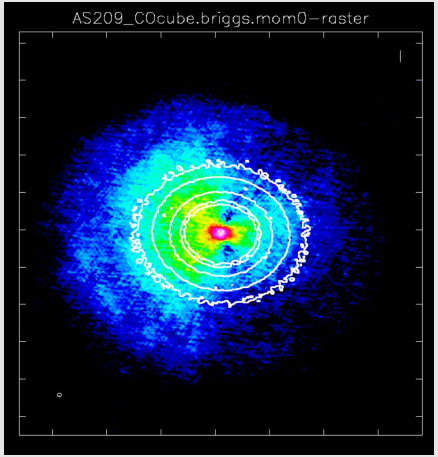
Moment 0 map

The integrated intensity over the spectral line

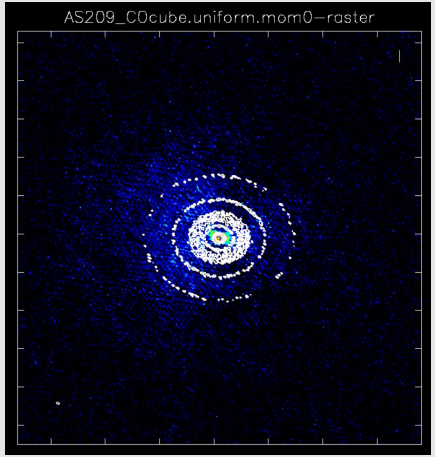
Natural



Briggs (robust=0.5)



Uniform

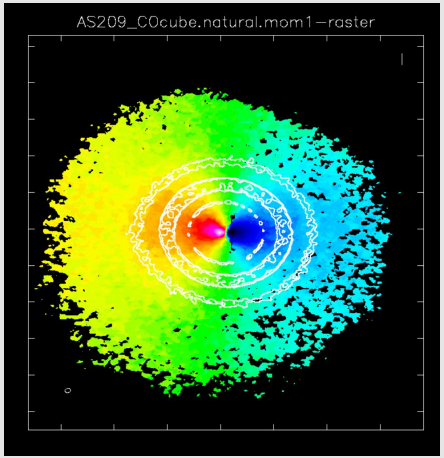


Moment Maps

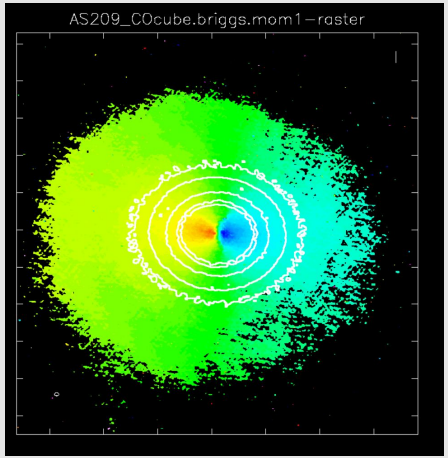
Moment 1 map

The intensity-weighted velocity of the spectral line

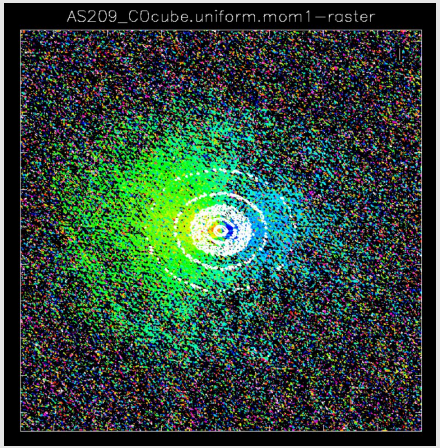
Natural



Briggs (robust=0.5)



Uniform

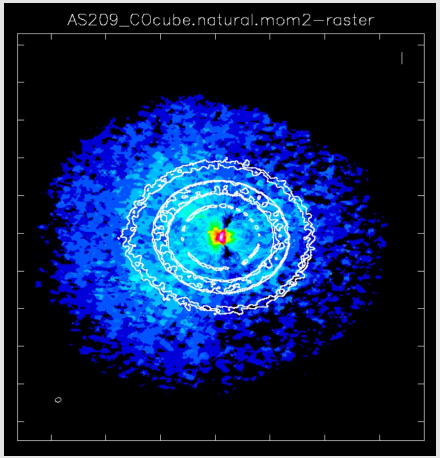


Moment Maps

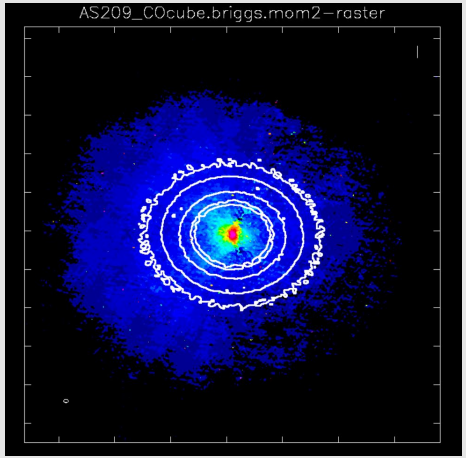
Moment 2 map

The velocity dispersion or the width of the spectral line

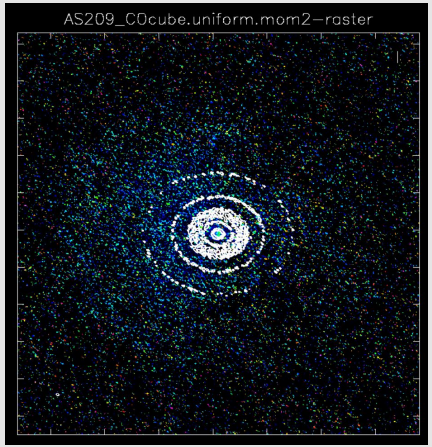
Natural



Briggs (robust=0.5)



Uniform



Central Star Mass Calculation

To calculate the central star mass, we need to use Kepler's law

$$m\frac{v^2}{r} = \frac{GMm}{r^2} \rightarrow M = \frac{rv^2}{G}$$

M: Central Star Mass

G: Gravitational constant

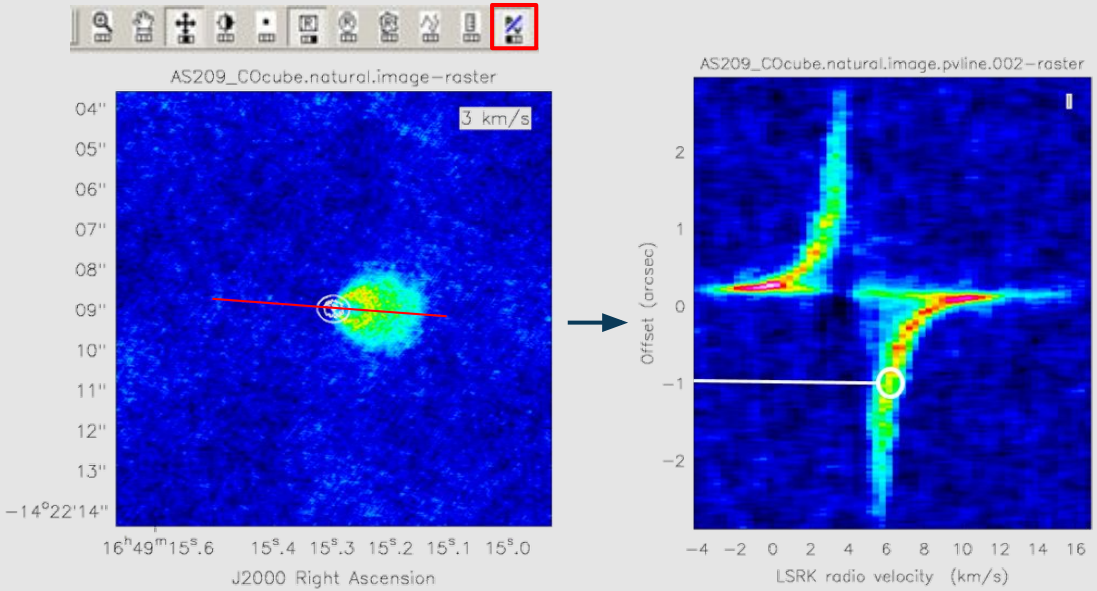
r: The distance between central star and gas (specific velocity)

v: Specific velocity of the gas

Using pv diagram

Central Star Mass Calculation

Position-Velocity Diagram (PV diagram)



The velocity of gas

6.1 km/s

(1 arcsec away)

The systemic velocity (v_{lsr})

4.6 km/s

(Guzmán at el. 2017)

The velocity of gas w.r.t systemic velocity

1.5 km/s

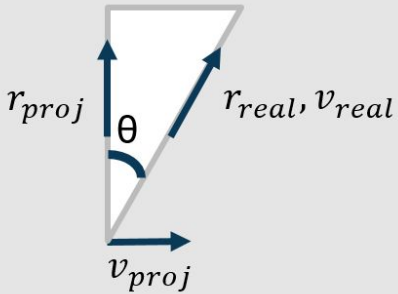
Central Star Mass Calculation

Real Distance and Velocity (consider projection about inclination)

The distance to the source ~ **121 *pc*** (Gaia Collaboration et al. 2018)

So, **1 arcsec≈121 AU** (using parallax)

We need to get real distance and real velocity considering projection about inclination(θ)



$$r_{real} = \frac{r_{proj}}{cos(\theta)} \longrightarrow r_{real} = \frac{121}{cos(\theta)}$$

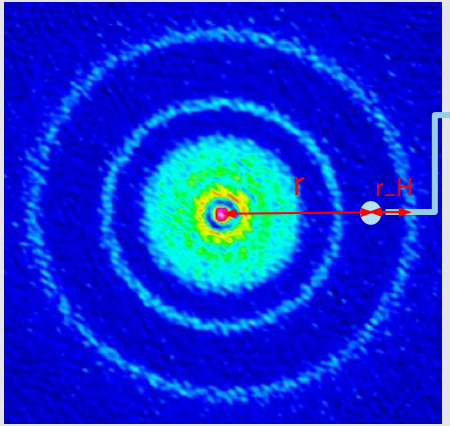
$$v_{real} = \frac{v_{proj}}{cos(\frac{\pi}{2} - \theta)} \longrightarrow v_{real} = \frac{1.5}{sin(\theta)}$$

Central Star Mass Calculation

Result

Inclination, θ = 36 deg, r_{real} = 149.6 AU, v_{real} = 2.6 km/s, ($0.9\ M_{\odot}$, Andrews et al. 2018)

$$M = \frac{rv^2}{G} = \frac{(149.6*1.496*10^{11})*(2.6*10^3)^2}{6.673*10^{-11}}\ kg = 2.27*10^{30}kg = 1.1M_{\odot}$$



Possible presence of planet?

Also, we will obtain planet mass using Hill Sphere

$$m = 3M\frac{(r_H * factor)^3}{r}$$

M = 1.1 $M_{\odot}$=1100 M_J , r = 0.7863 arc, r_H = 0.12 arc, $factor$ = ⅓

➡ m = 0.4 M_J (0.2 M_J , Guzman et al. 2018)

Thanks!

REFERENCES

Andrews et al. 2018
Guzman et al. 2018
Gaia Collaboration et al. 2018
Thi et al. 2001

Hill Sphere: https://en.wikipedia.org/wiki/Hill_Sphere

CREDITS: This presentation template was created by **Slidesgo**, including icons by **Flaticon**, and infographics & images by **Freepik**.

Please keep this slide for attribution.