Studying Infall Towards 10 Class 0/I Protostars Using ALMA Data and FERIA

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Introduction

The youngest protostars—in the Class 0/I phase—are elusive to detect, as they are heavily shielded by the gas and dust that collapses to form them. As of now, only ~25 Class 0/I protostars have had their mass measured, each in individual studies, not a systematic characterization.

This summer I modeled infall and rotation towards 10 Class 0/I protostars. This resulted in the first sample of protostars with masses measured systematically, using multiple dynamical models.

1

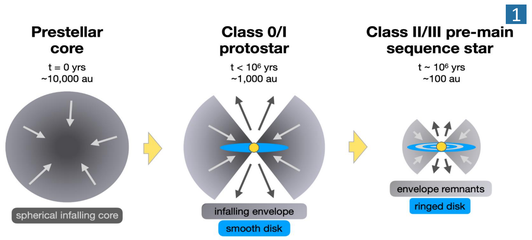


Figure 1 shows a schematic of the star formation process (Pineda et al. 2022 and Segura-Cox et al. in prep).

Methods

- We use FERIA: Flat Envelope model with Rotation and Infall under Angular momentum conservation (Oya et al. 2022)
- We calculate the X^2 between model and observed data cubes
- Using X^2, we rank our models, and after pruning the data, we recover parameters of the observed disk and protostar

2

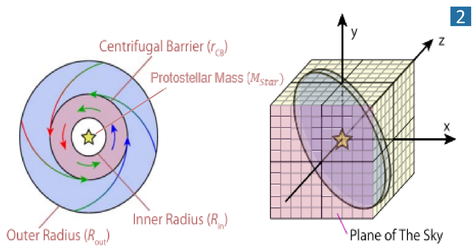


Figure 2 shows how FERIA makes image cubes, and uses parameters to model (Oya et al. 2022).

Figures and Models of the Class 0 Protostar Per-emb-14

3

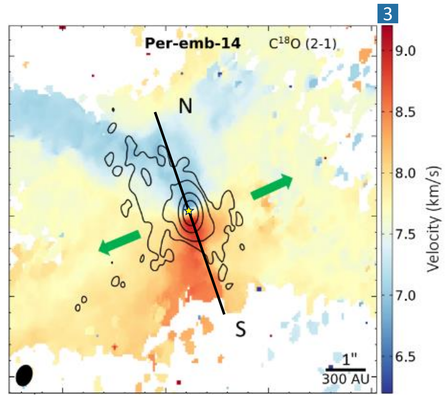


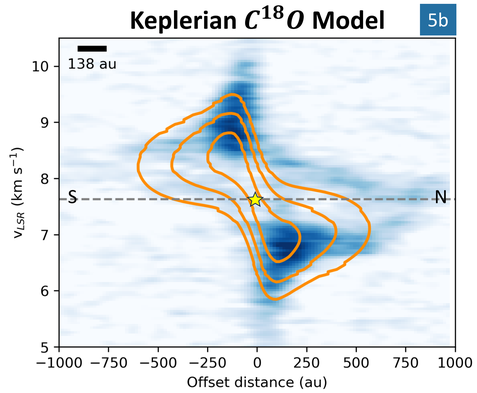
Figure 3 (above) shows our ALMA observations of $C^{18}O$ of Per-emb-14, with ~150AU resolution. We highlight the results of this source in this poster (Kirkpatrick et al. in prep).

Table 1: Parameters explored

Parameters	Range	Interval
Mass	0.1-1.5M_{Sun}	0.1M_{Sun}
Outer System Radius	100-1000AU	100AU
Inner Disk Radius	0-400AU	100AU
Centrifugal Barrier Radius	0-1000AU	50AU

- We conducted a grid search using FERIA through protostellar mass and disk characteristic radii
- ~5000 models were generated and analyzed
- X^2 comparisons were plotted using corner plots These were used to ensure we had well sampled the parameter-space, and search for trends in the model grids

5b



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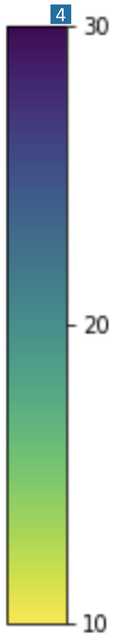


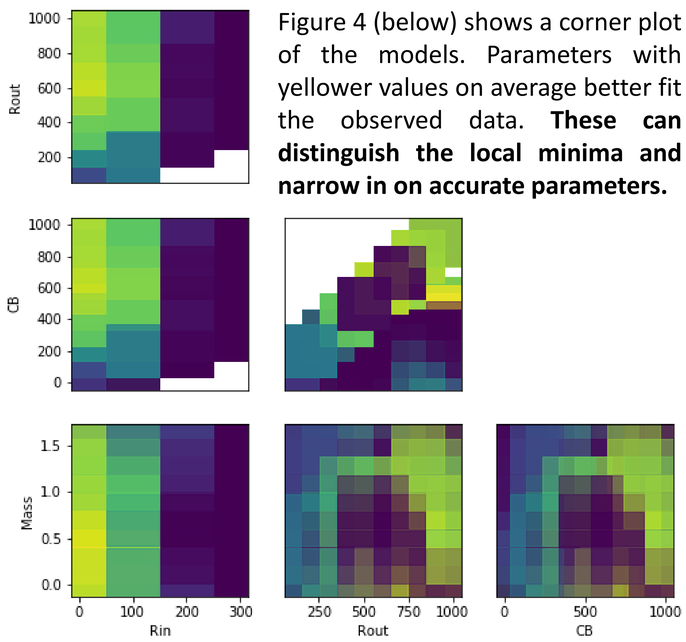
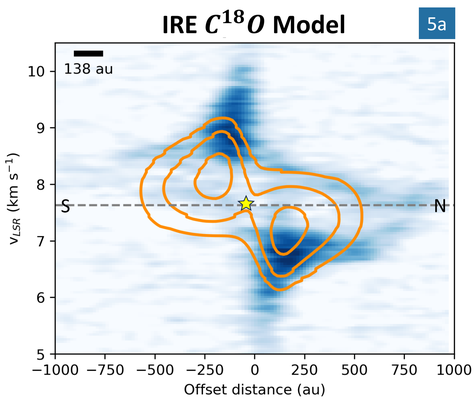


Figure 4 (below) shows a corner plot of the models. Parameters with yellower values on average better fit the observed data. **These can distinguish the local minima and narrow in on accurate parameters.**

5a



5c

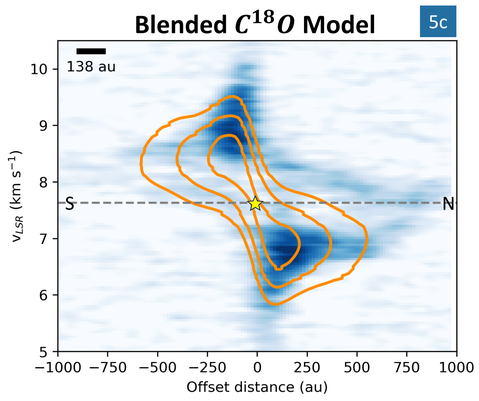


Figure 5a, 5b, and 5c (above) show our modeled Position-Velocity diagrams. We explore 3 scenarios: A Keplerian only model, a Infalling Rotating Envelope only model, and a combination of the 2. Color represents observed $C^{18}O$ data from a slice through the image cube along the long axis of the disk. Refer to Figure 3. Contours represent the best model for each scenario. **All 3 scenarios tend toward a similar morphology.**

Results

Per-emb-14	Reported Value
Mass	0.7 ± 0.4 M_{Sun}
Centrifugal Barrier Radius	60 ± 100 AU
Inner Disk Radius	30 ± 50 AU
Outer System Radius	550 ± 320 AU

Table 2 shows the reported values for Per-emb-14 derived from our methods.

Conclusion

- Using this method, mass for protostars can be well estimated, keeping within the range of known values
- Our reported mass value of 0.7 ± 0.4 M_{Sun} is consistent with Kirkpatrick et al. in prep's result of 0.67 M_{Sun} (which used a simpler method)
- At this resolution, disk radii are not well constrained. Higher resolution data may be needed to further constrain disk radii parameters

Acknowledgments

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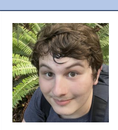

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