Protostellar Envelope around Class 0 YSOs: the Case of L1157

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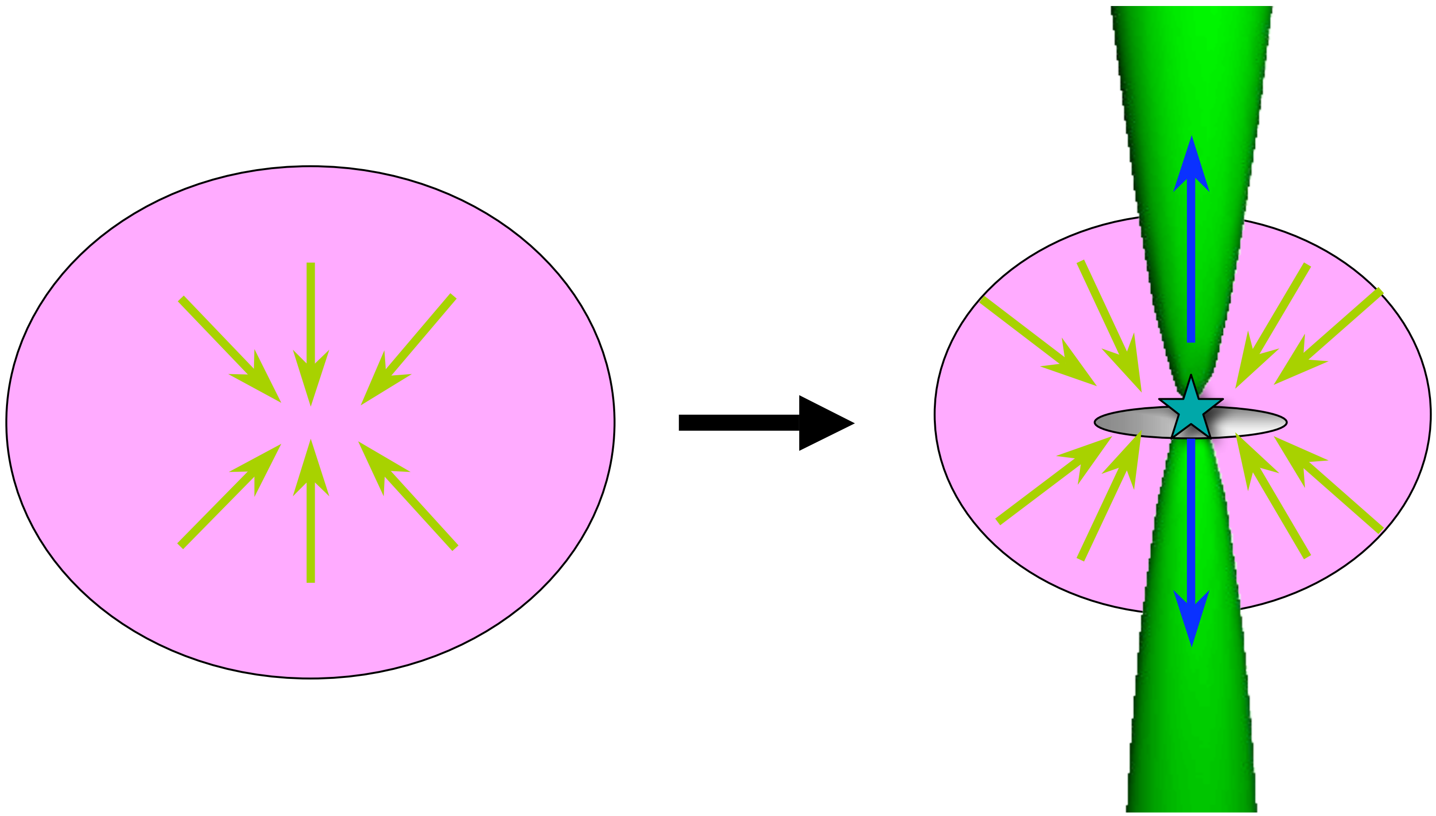
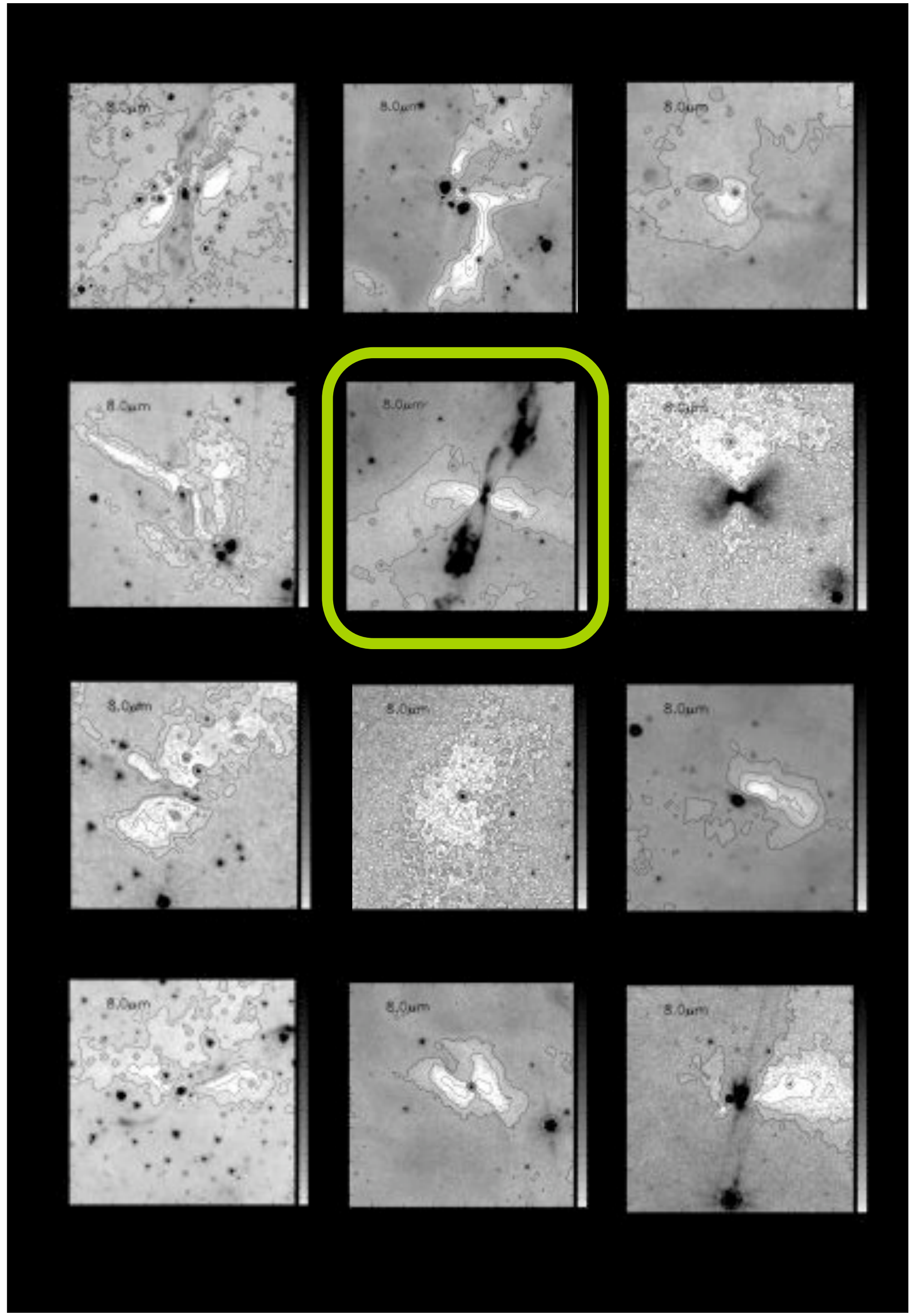
From Cores to YSOs



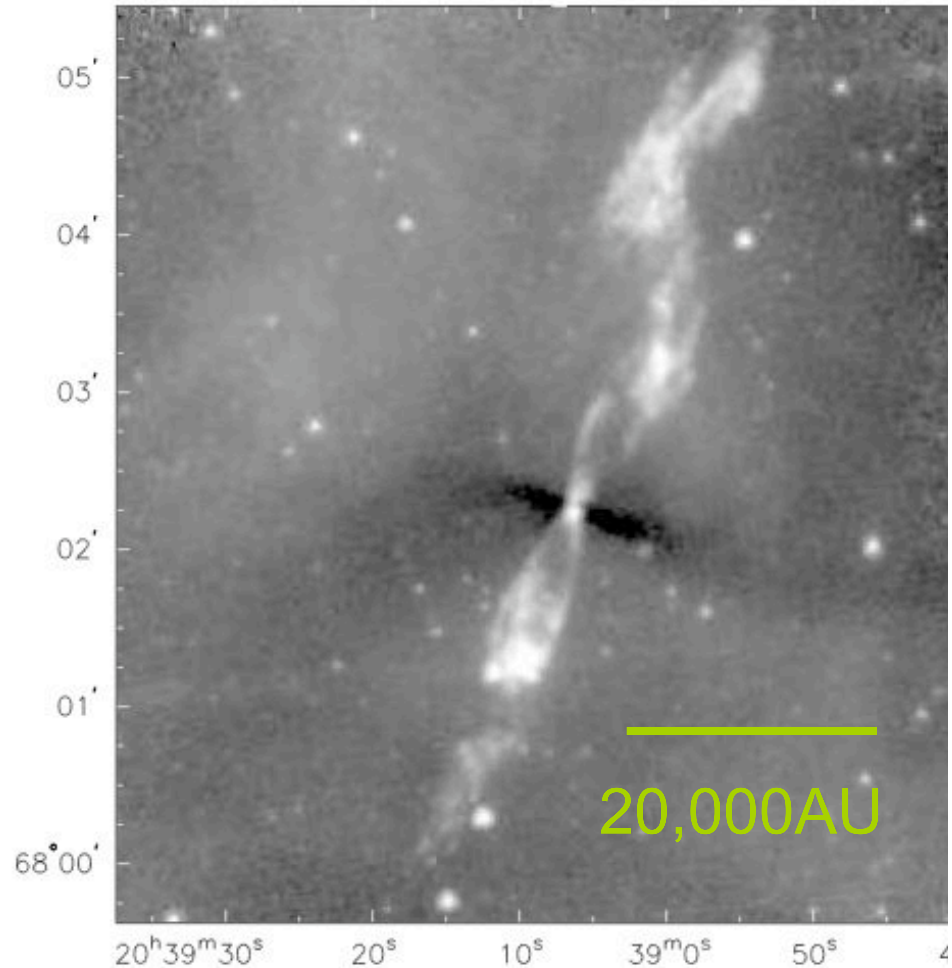
Complex structures in Class 0 envelopes

- 8 μm extinction of the outer envelopes mapped by Spitzer
- Non-axisymmetric structures from ~1000 AU to 0.1 pc scales (Tobin et al. 2010)



L1157-mm : a Class 0 YSO

- Isolated
- d ~250pc
- Outflows
- Nearly edge-on
- Large-scale disklike structure in 8 μm extinction



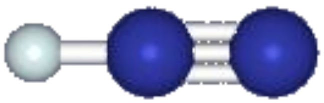
Spitzer IRAC 8 μm image (Looney et al 2007)

Our CARMA observations

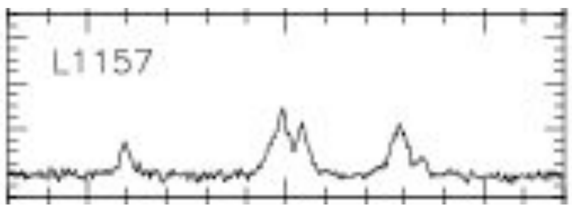
(Combined Array for Research in Millimeter-wave Astronomy)

N_2H^+ as the envelope tracer

- Rotational transition J=1-0
- Critical density ~ 10^5 cm^{-3}
- Outflow contamination minimized
- Hyperfine structure -- 7 components
- Isolated component JF_1F=101-012 at 93.176 GHz
- Observations → column density & velocity



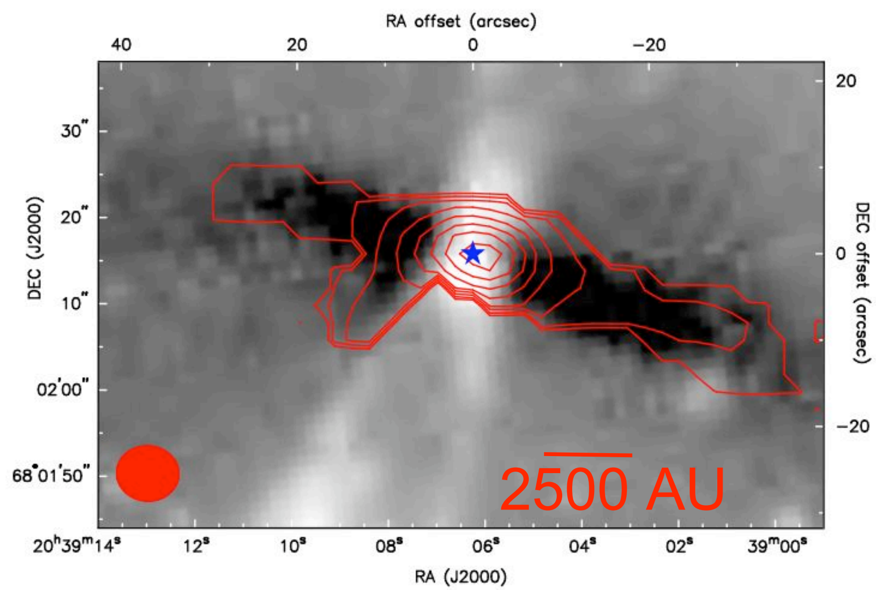
(credit:astrochymist.org)



IRAM 30m
(Emprechtinger et al. 2009)

N_2H^+ Flattened Envelope

- Flattening ⊥ outflow
- N_2H^+ contours follow 8 μm absorption

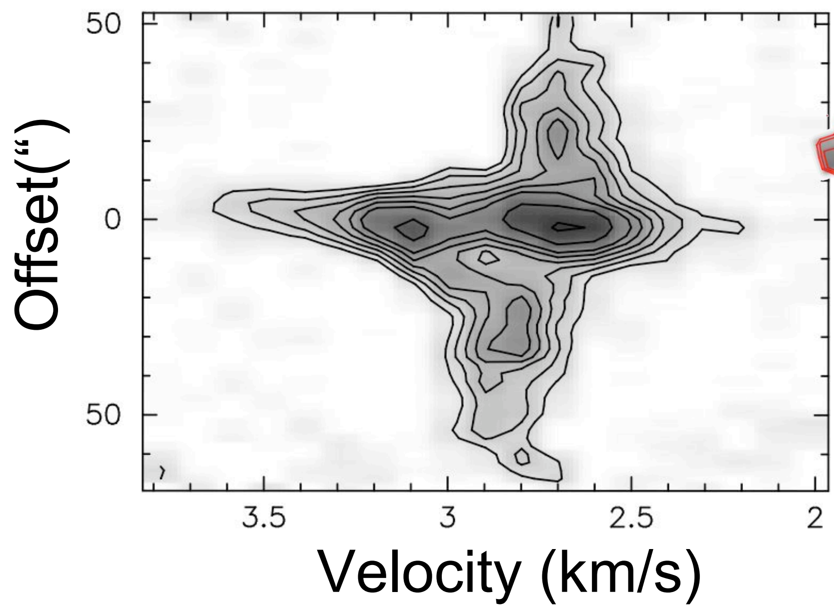


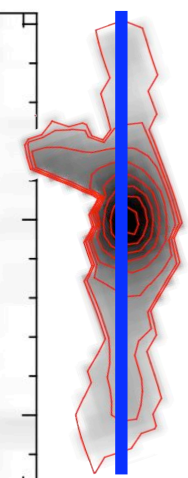
Chiang et al. 2010

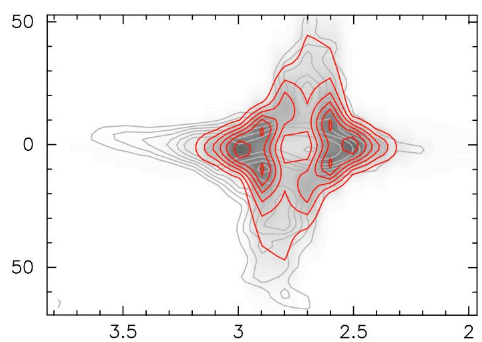
Gas kinematics

- Position-velocity diagram along the flattened envelope
- Double peaked feature
- Simple model
  e.g., Ohashi et al. 1997

- Infall
  previously suggested by e.g., Gregersen et al. 1997, Mardones et al. 1997
- Solid-body rotation: 1.5 km $s^{-1}pc^{-1}$







Chiang et al. 2010

Physical properties of this flattened envelope

- Size: d~20,000 AU
- Solid-body rotation: 1.5 km $s^{-1}pc^{-1}$
- Specific angular momentum ~$4x10^{-3}$ km $s^{-1}pc$

- Typical size of
  - Collapsing envelopes: 1000's AU
  - Prestellar cores: 10,000's AU
- Typical velocity gradient
  - class 0 YSOs: 7 km $s^{-1}pc^{-1}$
  - Prestellar cores: 1-2 km $s^{-1}pc^{-1}$

Caselli et al. 2002, Chen et al. 2007

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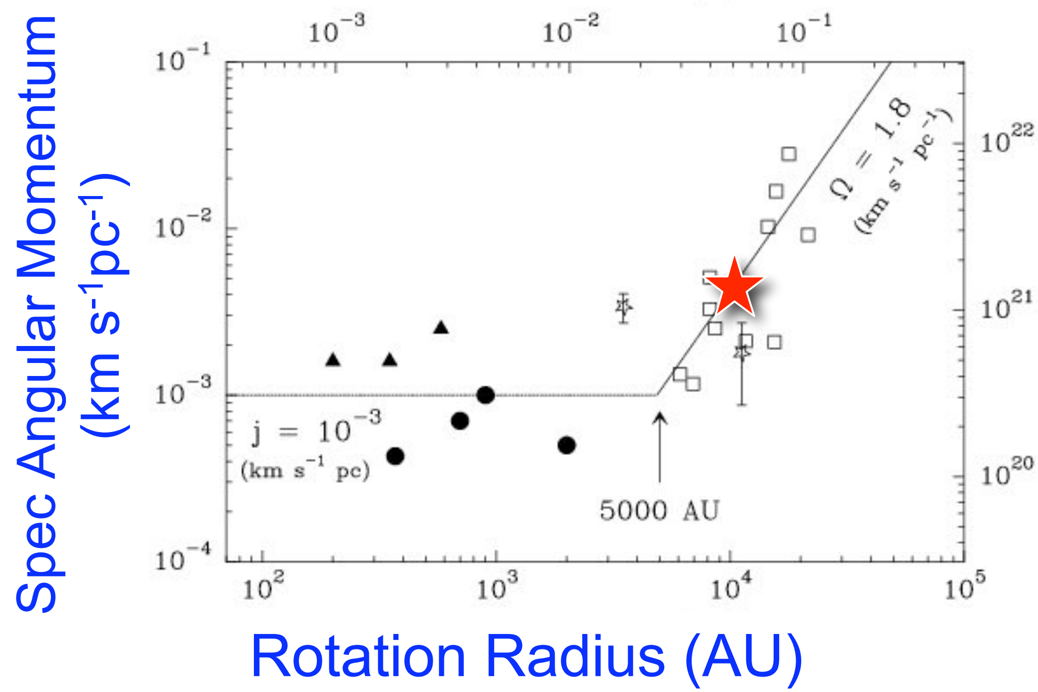
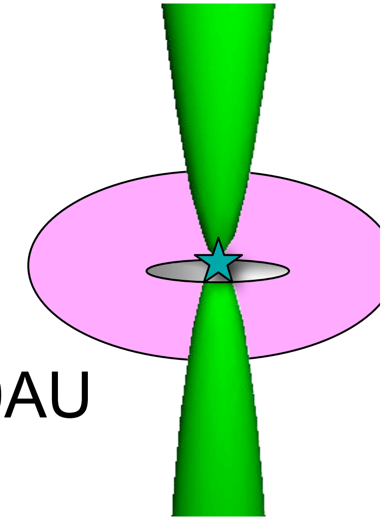


Ohashi et al. 1997, Belloche et al. 2002

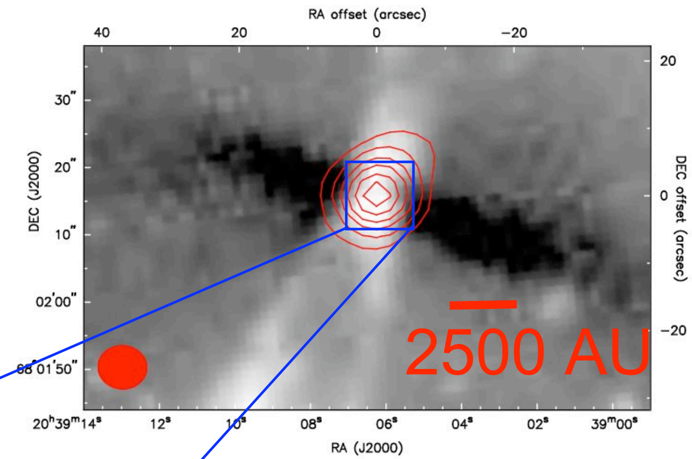
Circumstellar disks at small scale?



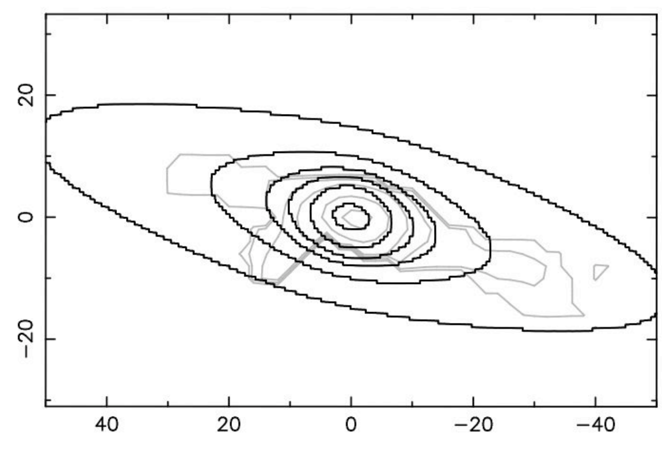
- Fitted angular velocity → centrifugal radius ~500AU
- Theoretical models → disk?
- Observations of most class 0 YSOs require compact continuum emission (i.e., disk component) (Looney+2003, Jorgensen+2009, Enoch+2009)
- Class 0 YSO IRAS4B shows tentative velocity gradient 7700 km $s^{-1}pc^{-1}$ at 25 AU scale (Jorgensen & van Dishoeck 2010)

Dust continuum observations

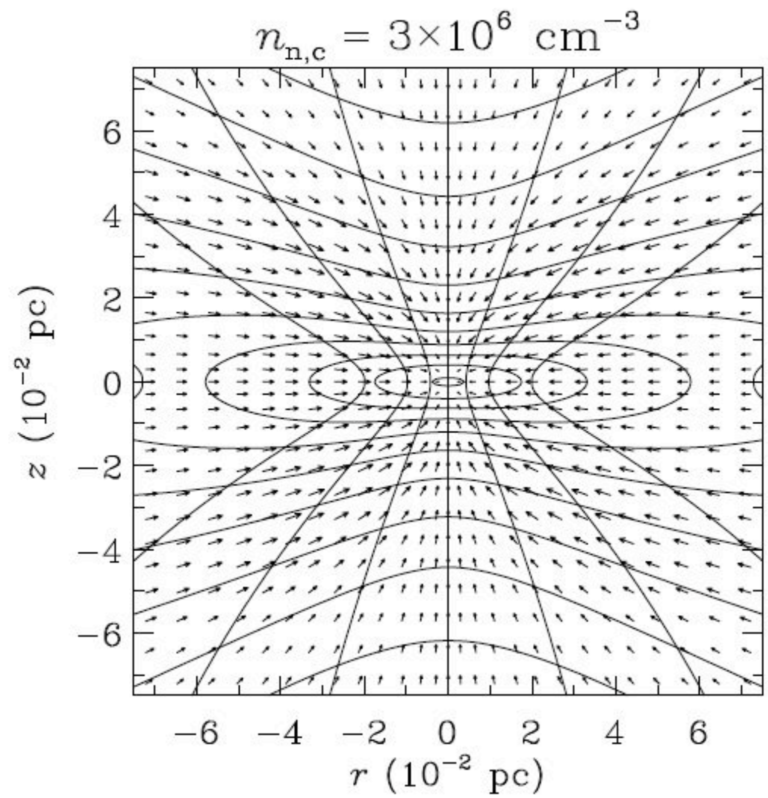
- CARMA obs at 3mm
- Nearly spherical compact dust continuum

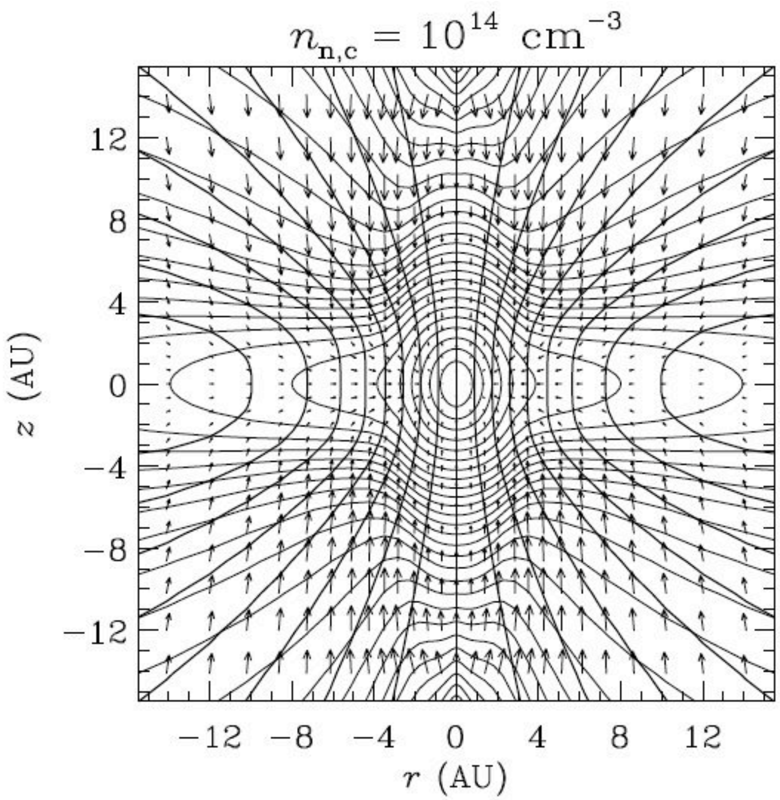


- Ad hoc model that is consistent with both gas and dust structures



Example: model of Kunz & Mouschovias (2010)

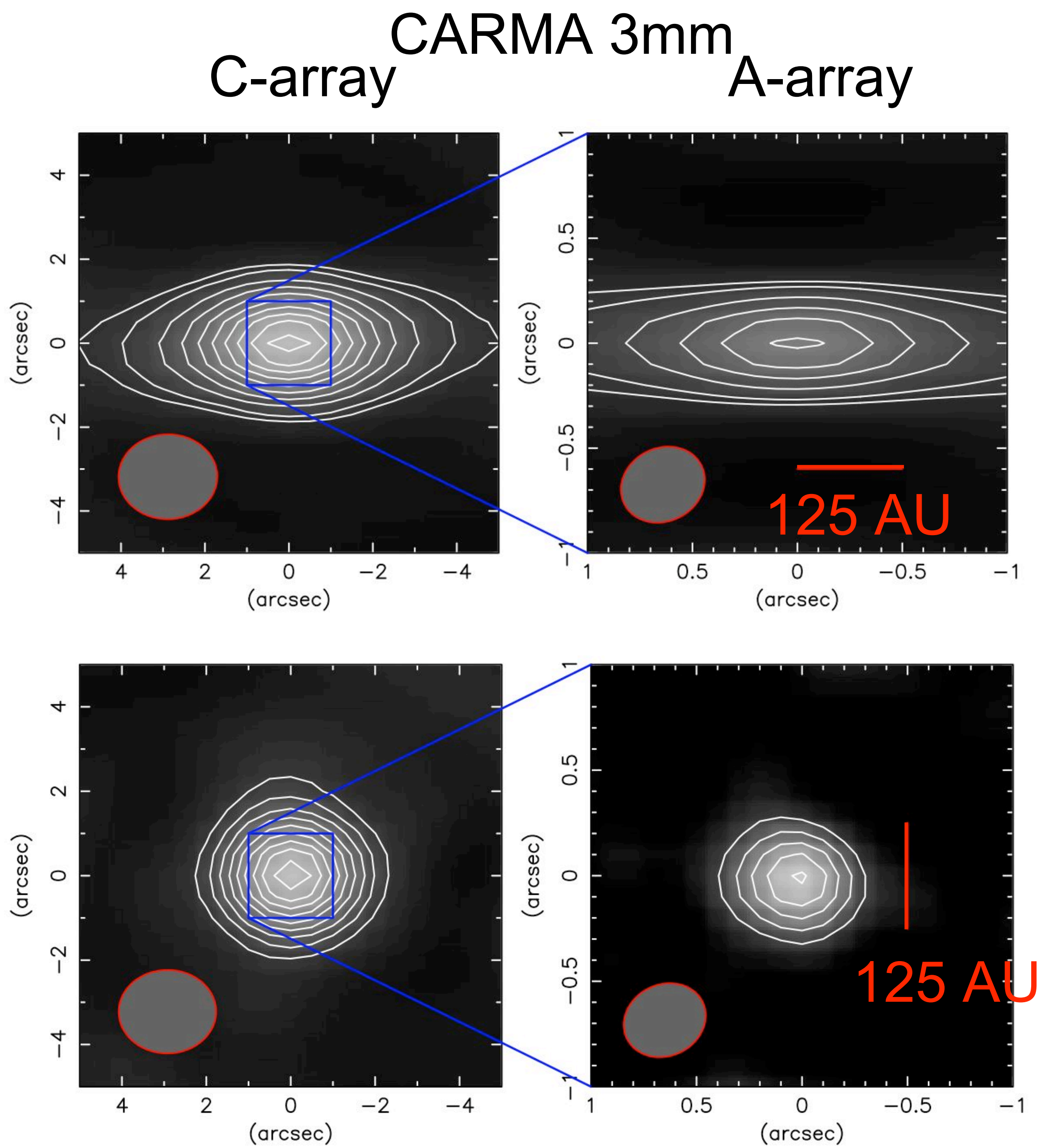




Preliminary

- Class -I
  Simulated observations

- Class 0
  L1157



Uncertainties: age, outflow effects, grain properties, projection effects, etc

Conclusions

- A large-scale N_2H^+ envelope, similar to 8 μm extinction feature, around the Class 0 YSO L1157
- Flattened N_2H^+ envelope at large scales
- Envelope kinematics: infall + solid-body rotation
- The flattened envelope resembles a prestellar core, while the inner part is decoupled and undergoing gravitational collapse
- High resolution observations show compact nearly-spherical dust continuum at small scales
- ALMA will reveal the inner envelopes and early disks

Reference

- Belloche et al. 2002 A&A 393, 927
- Caselli et al. 2002 ApJ 572, 238
- Chen et al. 2007 ApJ 669, 1058
- Chiang et al. 2010 ApJ 709, 470
- Emprechtinger et al. 2009 A&A 493, 89
- Enoch et al. 2009 ApJ 707, 103
- Jorgensen et al. 2009 A&A 507, 861
- Jorgensen & van Dishoeck 2010 ApJL 710, 72
- Kunz & Mouschovias 2009 ApJ 693, 1895
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- Looney et al. 2003 ApJ 592, 255
- Looney et al. 2007 ApJL .670, 131
- Ohashi et al. 1997 ApJ 488, 317
- Tobin et al. 2010 ApJ 712, 1010