

# Magnetics Fields and L1157

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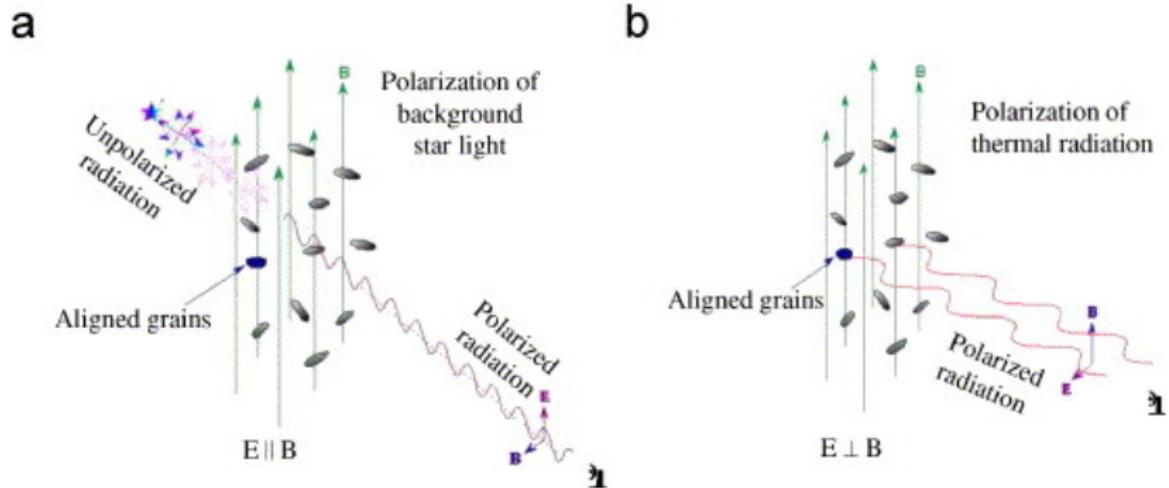
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# Outline

- **Polarization** and **magnetic fields** and how they relate to **star formation**
- Protostar L1157-mm and its outflow
- Magnetic field morphology about L1157-mm
- **Pizza** and **Beer**

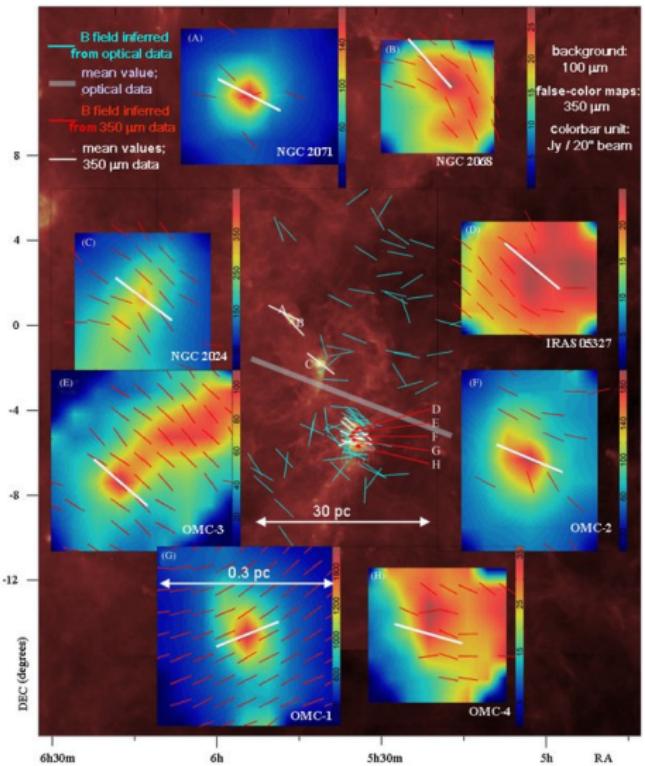
## Grain Alignment Causes Polarization



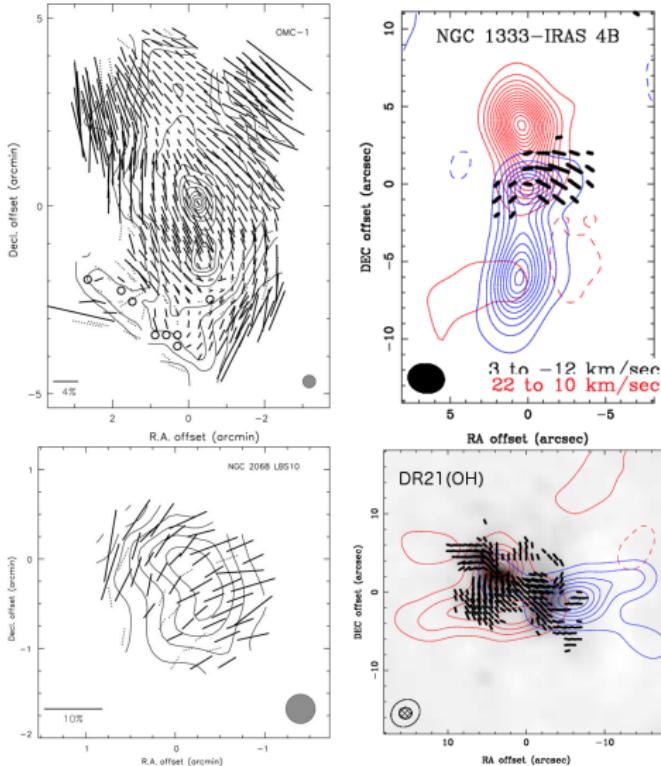
Lazarian (2007)

- a) Inferred  $\vec{B}$  is parallel to  $\vec{E}$ .
- b) Inferred  $\vec{B}$  is perpendicular to  $\vec{E}$ .

# Structured Magnetic Fields



Li et al. (2009)



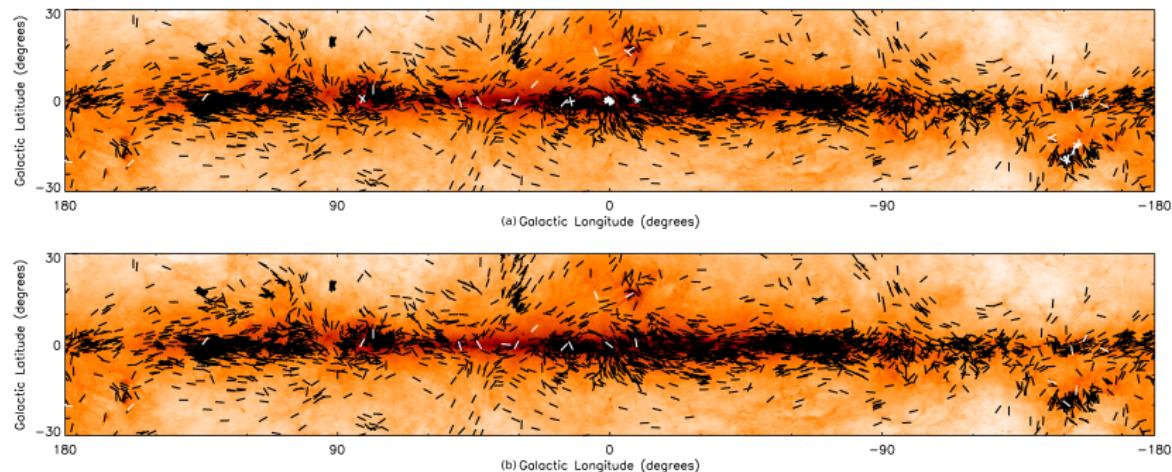
Dotson et al. (2010)

Hull et al. (in prep)

# Star Formation and Magnetic Fields

Black Vectors: B-field from Optical Data (Heiles 2000)

White Vectors: Average 350  $\mu\text{m}$  vectors from Dotson et al. (2010) catalog

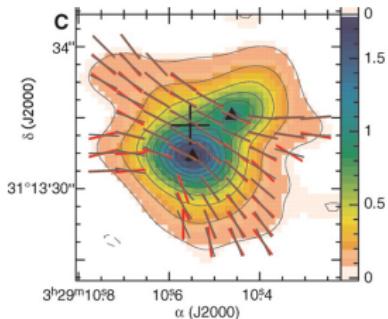


Stephens et al. (2011)

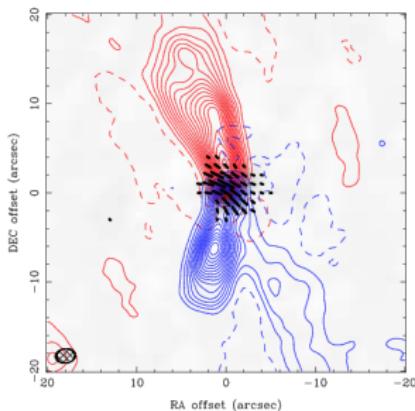
Star Formation is decoupled from the Galactic disk's magnetic field (kpc size-scale)  $\Rightarrow$  star formation is its own dynamical process

# Star Formation and Magnetic Fields

- Collapsing cloud magnetic field morphology should be an hourglass shape
- Full hourglass morphology for low-mass star formation rarely seen!
- Several high-mass detections of full hourglass (e.g., Schleuning 1998; Girart et al. 2009; Tang et al. 2009)
- Only full hourglass for low-mass stars: NGC 1333 IRAS 4A (Girart et al. 1999)



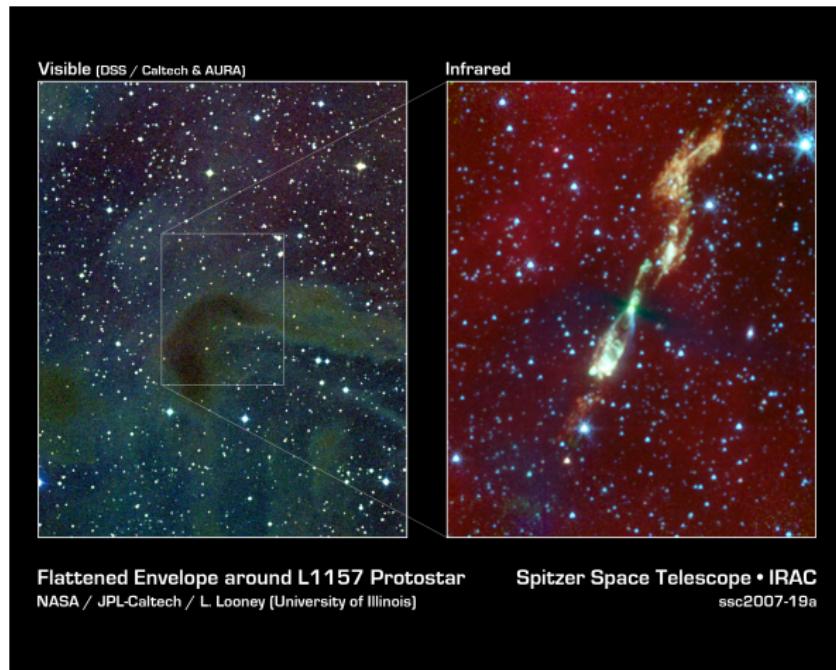
Girart et al. (2006)



Hull et al. (in prep)

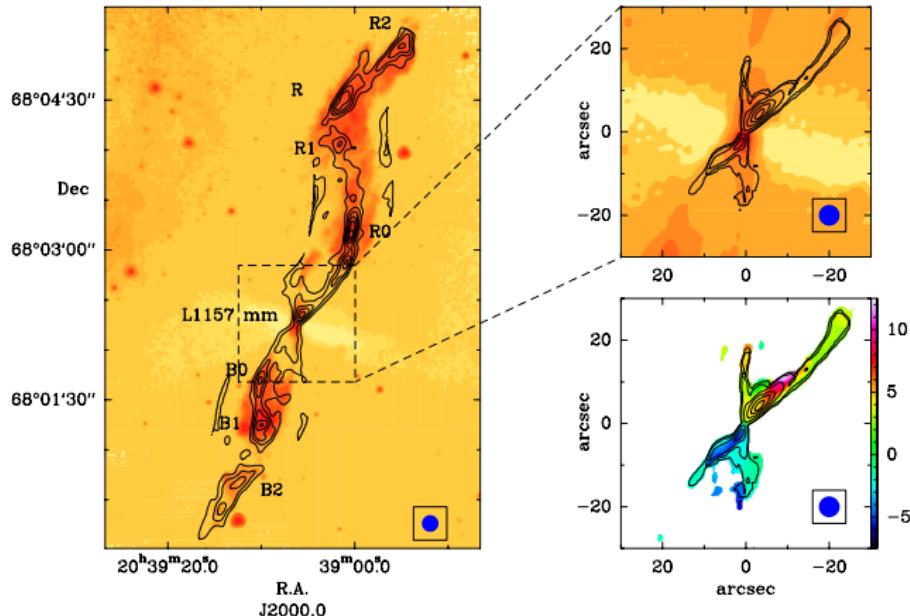
# L1157 Introduction

- Located about 250 pc away
- Contains low-mass Class 0 protostar L1157-mm
- Outflow spanning 5'



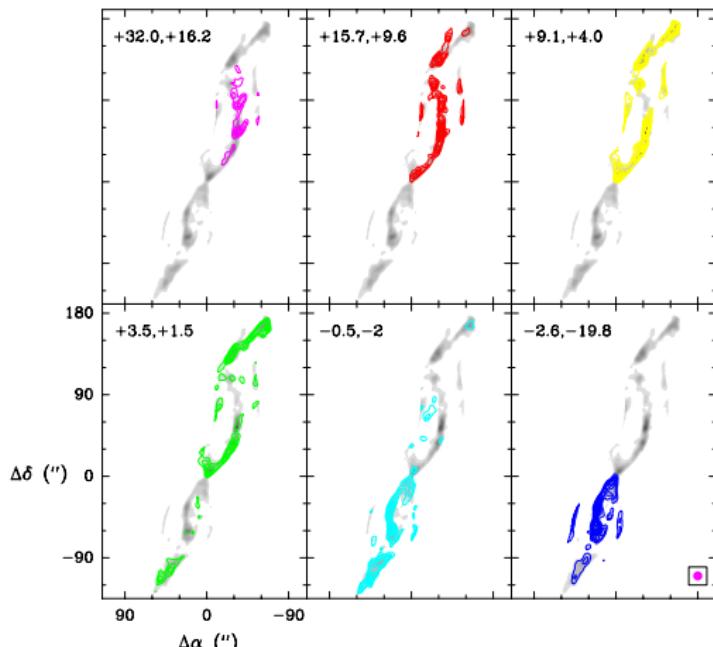
# L1157 Introduction

## L1157-mm Outflow with CARMA



Kwon et al. (in prep)

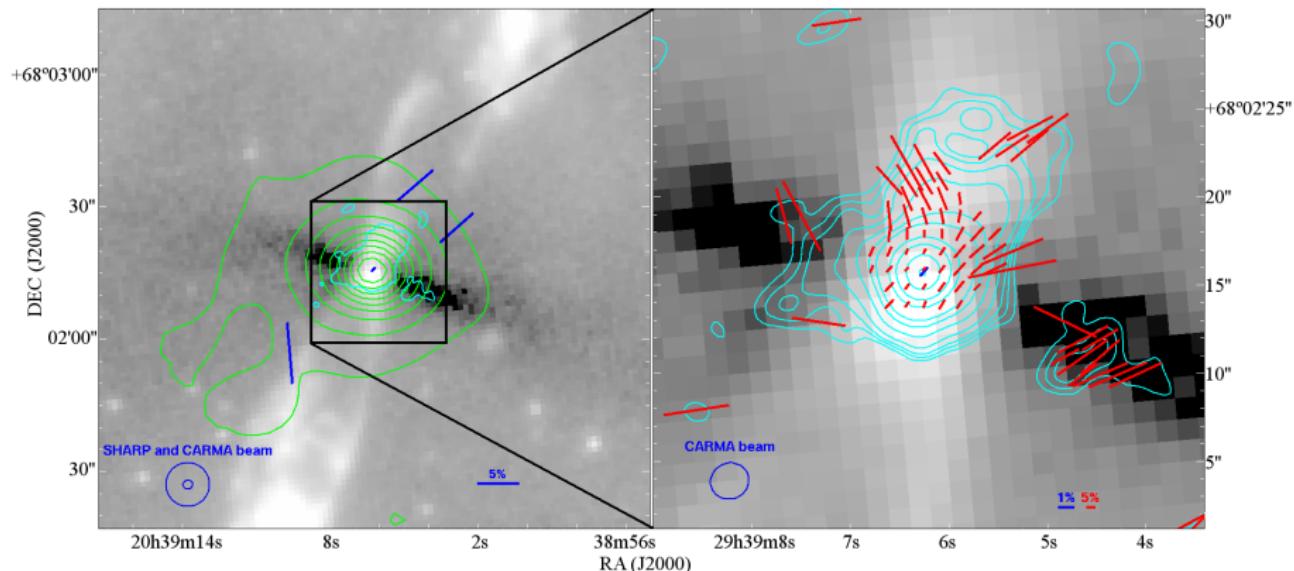
## L1157-mm Outflow with CARMA



Kwon et al. (in prep)

# L1157 Magnetic Field Morphology

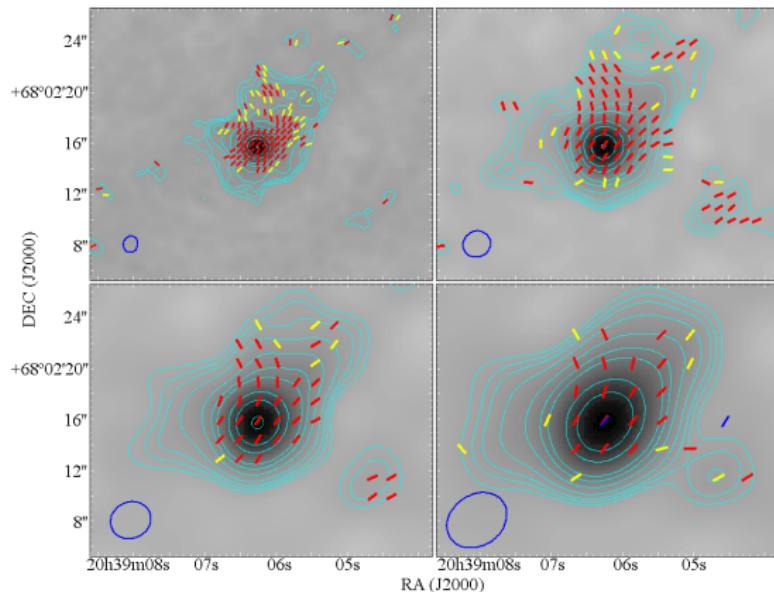
- Inferred magnetic field morphology in L1157
- CSO: Blue Vectors/Green Contours
- CARMA: Red Vectors/Cyan Contours



Stephens et al. (2013)

# L1157 Magnetic Field Morphology

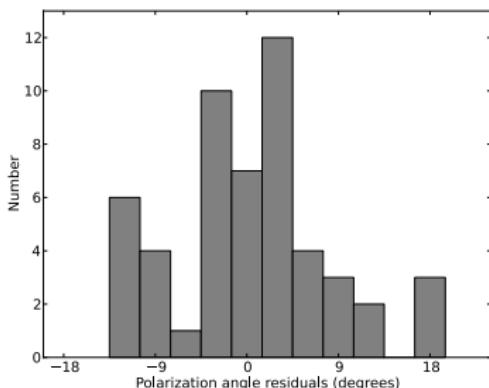
- Top left: 1.2'' resolution, top right: 2.1'' resolution, bottom left: 3.0'' resolution, and bottom right: 4.5'' resolution
- CARMA: Red Vectors/Cyan Contours



Stephens et al. (2013)

# L1157 Magnetic Field Magnitude

- Plane-of-sky magnetic field strength using Chandraeskar-Fermi technique
- Fit parabolas to vectors, standard deviation of residuals
- N<sub>2</sub>H<sup>+</sup> velocity dispersion
- Magnetic field strength of 1.4 mG, 1.1 times the critical value for collapse

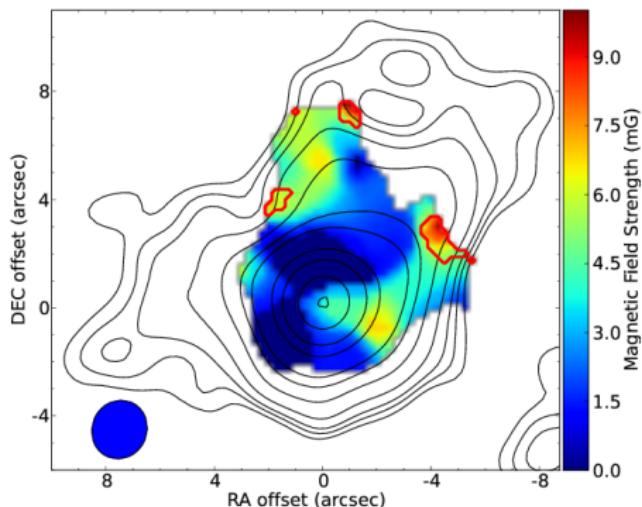


Stephens et al. (2013)

# L1157 Magnetic Field Magnitude

- Plane-of-sky magnetic field strength using the method from Koch et al. (2012)
- Red contours: subcritical (magnetic field tension dominates gravity)

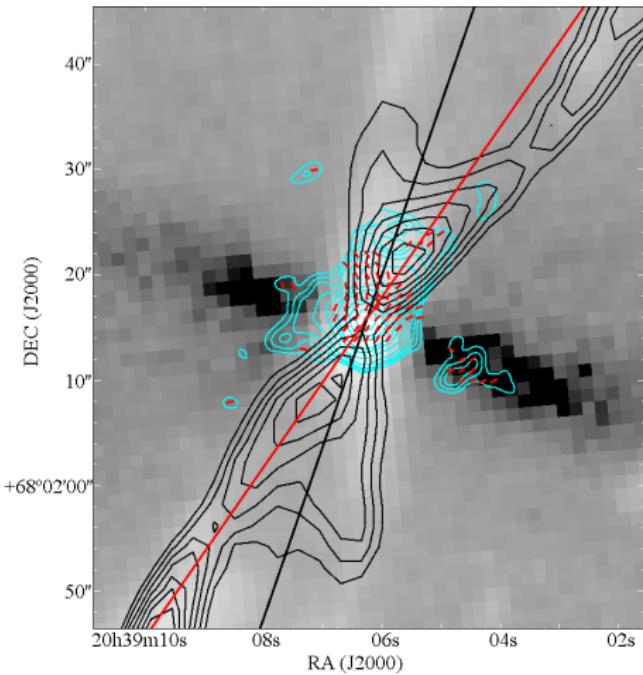
$$B = 3.4 \text{ mG} \left(\frac{\rho}{2}\right)^{1.9} \left(\frac{M_{\text{protostar}}}{0.19 M_{\odot}}\right)^{0.5} \left(\frac{d_{L1157}}{250 \text{ pc}}\right)^{0.5} \text{ where } \rho \propto r^{-p}$$



Stephens et al. (2013)

# L1157 Magnetic Field Morphology

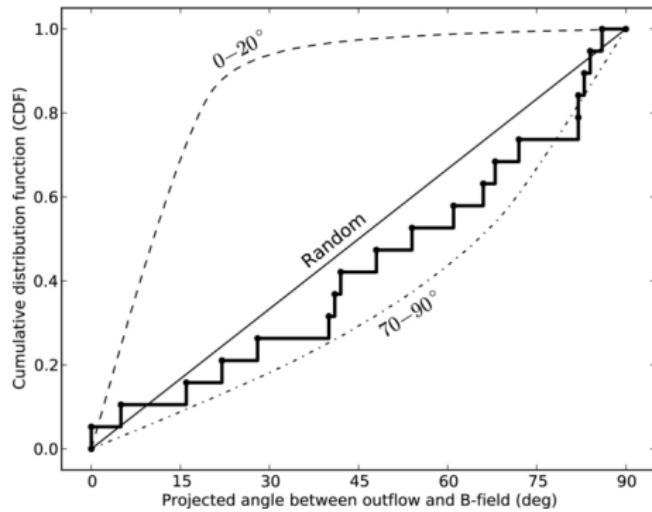
- Outflow aligned with hourglass axis!
  - ▶ Red line: hourglass axis
  - ▶ Black line: Center of outflow (Bachiller et al 2001)
  - ▶ Aligned perfectly with CO intensity peaks



Stephens et al. (2013)

# L1157 Magnetic Field Morphology

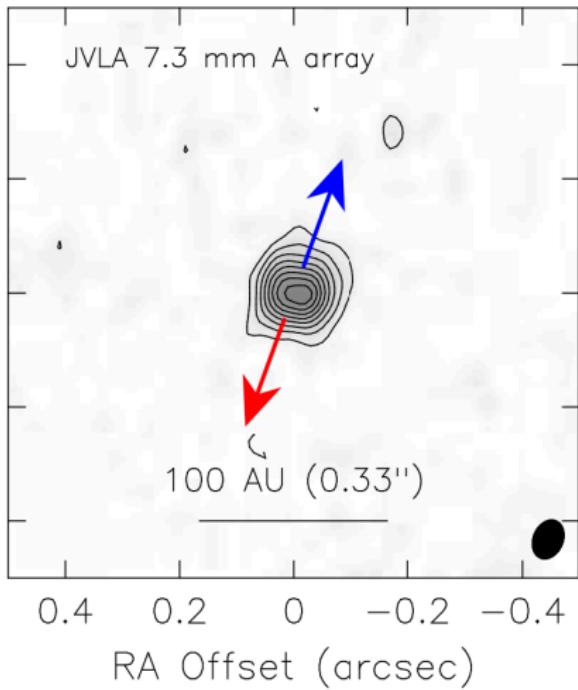
- Outflow aligned with hourglass axis is actually very rare.
- CARMA key project TADPOL shows consistency with randomly aligned and preferentially misaligned!
  - New results suggest higher polarized sources are randomly aligned while lower polarized sources are misaligned (Hull et al. in prep).
- Is L1157 alignment a statistical fluctuation?
  - ▶ Single source  $\sim 15$  AU resolution in plane-of-sky



Hull et al. (2013)

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Tobin et al. (submitted)

# Conclusions

- Magnetic fields and star formation are related
  - ▶ Magnetic fields aligned within the cloud accumulation scale
  - ▶ However, is decoupled from the large-scale Galactic disk field
- L1157-mm has magnetic fields aligned with outflow
  - ▶ Rare situation
  - ▶ Second well-defined hourglass morphology around a low-mass protostar

Pizza and Beer

