Magnetic fields surrounding LkHα 101

taken by the JCMT BISTRO survey

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LkHα 101 Region

Highest star-formation efficiency in Auriga

33 candidate protostars with an only early-B star

Why is the star-formation efficiency low in Auriga?

Colored points: YSOs

LkHα 101

Auriga–California cloud

Broekhoven-Fiene+ 2018
Grain Alignment

FIR/Sub-millimeter Dust thermal emission

B-field

Polarization

E.g. Lazarian & Hoang 2007
**B-field morphology**

**Central region**: the field lines are perpendicular to each other running north-south and east-west

**Dust lane**: the B-fields has the tendency to follow the filamentary structure

Map of the B-field orientation (line segments) overlaid on the intensity map. The contours ~ 15 and 250 mJy/beam
Magnetic field strength: Davis, Chandrasekhar & Fermi method

- $n(H_2)$: volume density
- $\Delta V$: velocity dispersion
- $\sigma_\theta$: polarization angle dispersion
  - Unsharp masking
  - Structure function

$$B_{\text{POS}} \approx 9.3 \sqrt{n(H_2)} \frac{\Delta V}{\sigma_\theta}$$

~ gas density  ~ Alfven velocity

(Crutcher 2004)
**n(H₂): volume density**
\[ N(H_2) \text{ Herschel} \]

**ΔV: velocity dispersion**
\[ \text{CO}(3-2) \text{ HARP/JCMT} \]

**aHerschel column density map**

**JCMT/HARP CO(3–2) integrated spectra**
Polarization angle dispersion: Unsharp masking method \((\text{Pattle+2017})\)

\[
\Delta \theta = \theta_{\text{meas}} - \langle \theta \rangle \rightarrow \text{angle dispersion } \sigma_\theta
\]
Polarization angle dispersion: Structure function method (Hildebrand+2009)

\[ <\Delta \theta^2(l)> \approx b^2 + m^2 l^2 \]
\[ \sigma_{\theta}^2 = b^2 / 2 \]

Central region  
\[ \sigma_{\theta} = 13.7^\circ \pm 4.2^\circ \]

Dust lane  
\[ \sigma_{\theta} = 15.9^\circ \pm 4.4^\circ \]

Dispersion of polarization angles of all pairs of pixels having a distance \( l \) (arcsec)
Mass-to-flux ratio

$$\lambda = 7.6 \times 10^{-21} \frac{N(H_2)}{B_{pos}}$$  Crutcher 2004

Regions are **subcritical**

=> the fields are strong enough to resist gravitational collapse

=> support the **low star forming efficiency** found in Auriga-California

<table>
<thead>
<tr>
<th></th>
<th>Central region</th>
<th>Dust lane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsharp Masking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_{POS} (\mu G)$</td>
<td>$91\pm32$</td>
<td>$132\pm27$</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>$0.27\pm0.15$</td>
<td>$0.28\pm0.12$</td>
</tr>
<tr>
<td><strong>Structure Function</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_{POS} (\mu G)$</td>
<td>$92\pm42$</td>
<td>$144\pm36$</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>$0.27\pm0.16$</td>
<td>$0.32\pm0.15$</td>
</tr>
</tbody>
</table>

$\lambda$: smallest in BISTRO
Polarization hole

Segment length $\sim P(\%)$

Causes (?)

- B-field tangling
- Or/and
- Radiative Torque Disruption (RATD)

$P \propto I^\alpha$

$\alpha = 0.82 \pm 0.03$

Distance from the B star
**RAdiative Torque Alignment (RATA) vs RAdiative Torque Disruption (RATD)**

**RATA prediction:**
P (%) increases with increasing $T_{dust}$

**RATD prediction:**
P (%) increases and then decreases with increasing $T_{dust}$

E.g. Lazarian & Hoang 2007

Radiation strength $\sim$ Dust temperature ($T_{dust}$)

Hoang, Tram + 2019
LkHα 101: Central region

Input parameters for the model

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td></td>
</tr>
<tr>
<td>$S_{\text{max}}$</td>
<td>$10^7$ erg cm$^{-3}$</td>
</tr>
<tr>
<td>Axial ratio</td>
<td>0.333</td>
</tr>
<tr>
<td>Volume density of dust grains, $\rho$</td>
<td>3 g cm$^{-3}$</td>
</tr>
<tr>
<td>$a_{\text{min}}$</td>
<td>10 Å$^0$</td>
</tr>
<tr>
<td>$a_{\text{max}}$</td>
<td>1 μm</td>
</tr>
<tr>
<td>Size distribution power index, $\beta$</td>
<td>-3.5 or -4</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{gas}}$</td>
<td>20 K</td>
</tr>
<tr>
<td>$n_{\text{H}}$</td>
<td>$1.22 \times 10^4$ cm$^{-3}$</td>
</tr>
<tr>
<td>Ambiance</td>
<td></td>
</tr>
<tr>
<td>Mean wavelength, $\lambda$</td>
<td>0.45 μm</td>
</tr>
<tr>
<td>Anisotropy degree of radiation field, $\gamma$</td>
<td>1</td>
</tr>
</tbody>
</table>

Lee+ 2020

P(%) vs. $T_{\text{dust}}$ (K) RAT predictions

RAT Alignment

RAT Disruption
JCMT proposal accepted two more fields: explore the criticality of the region.
Conclusions

- We performed the first high resolution measurement of magnetic field surrounding the LkHα-101 region. The measured field strength is ~ 100 μG.
- Mass-to-magnetic-flux-ratio $\lambda \approx 0.3$ supports for the low star forming efficiency of Auriga-California (LkHα-101 is the densest region of Auriga).
- The polarization fraction decreasing with increasing proximity to the only B star of the region (polarization hole) can be explained by the joint effect of RAT-A and RAT-D or the field tangling.
- A 22A proposal to observe two more fields in Auriga with JCMT/POL-2 is accepted, it will be interesting to study more about the B-fields, criticality, and dust physics in the region.

Thank you for your attention!