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Magnetic fields surrounding LkHα 101 taken by the JCMT BISTRO survey

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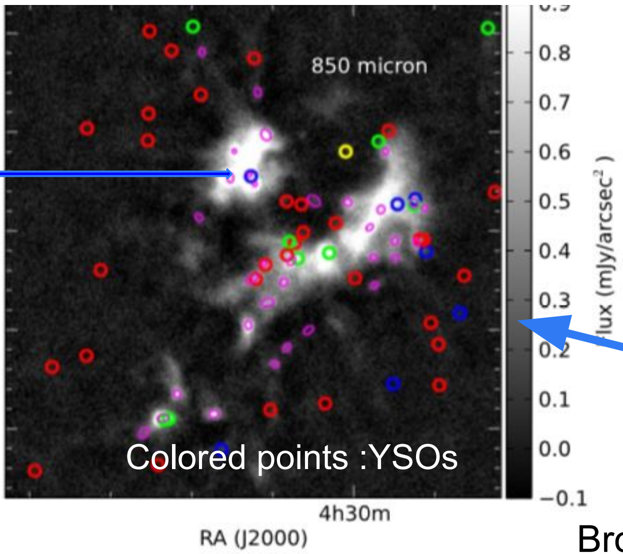
JCMT meeting, 2022

LkHα 101 Region

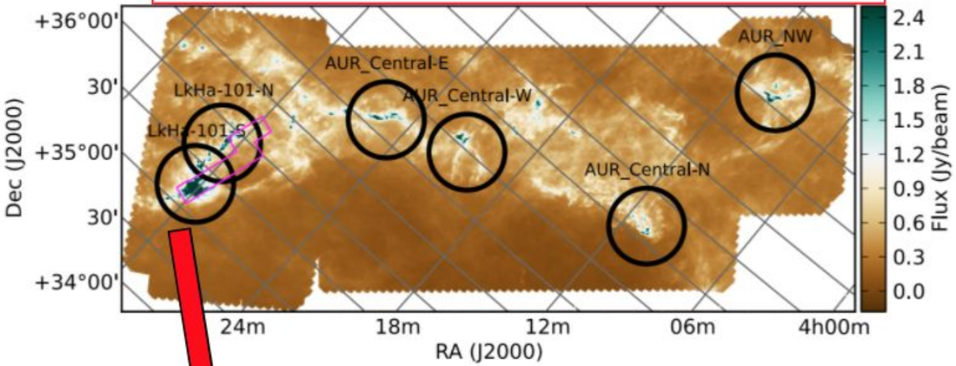
Highest star-formation efficiency in Auriga

33 candidate protostars with an only early-B star

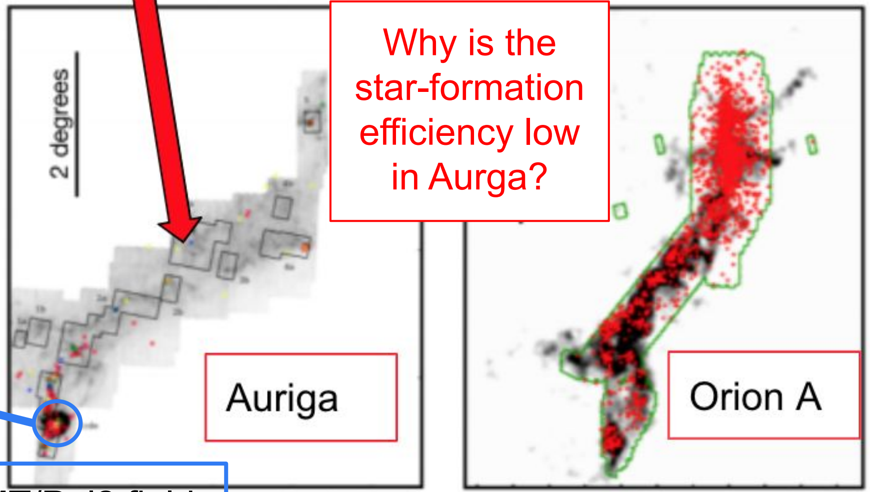
LkHα 101



Auriga–California cloud



Why is the star-formation efficiency low in Aurga?



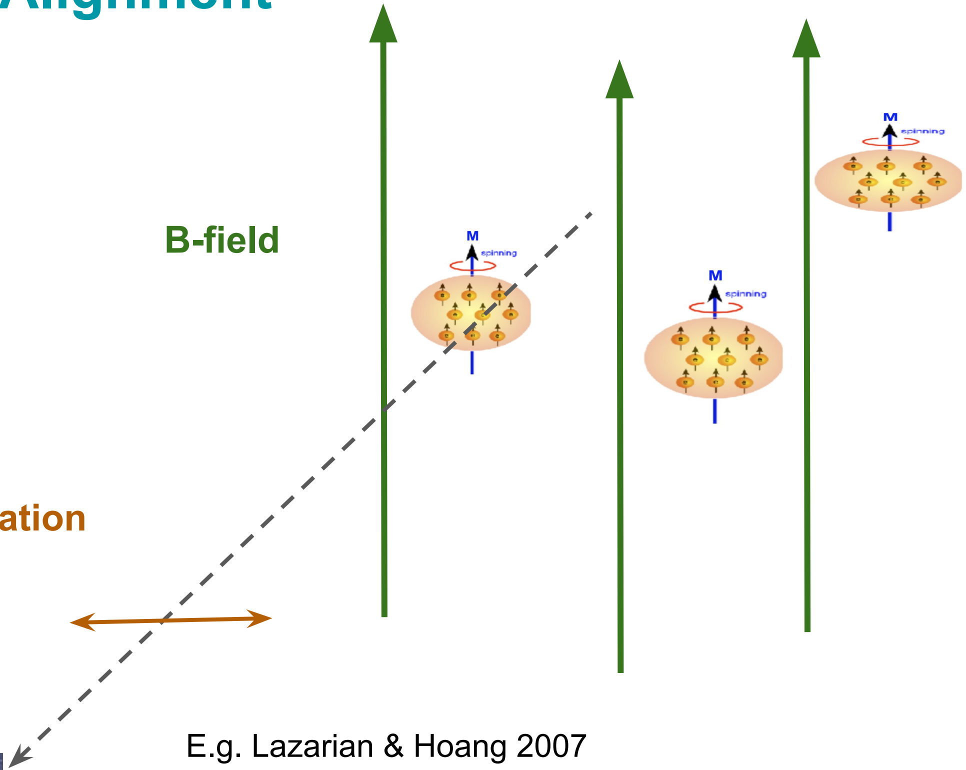
JCMT/Pol2 field

Broekhoven-Fiene+ 2018

red dots: protostars

Grain Alignment

FIR/Sub-millimeter
Dust thermal emission



Polarization

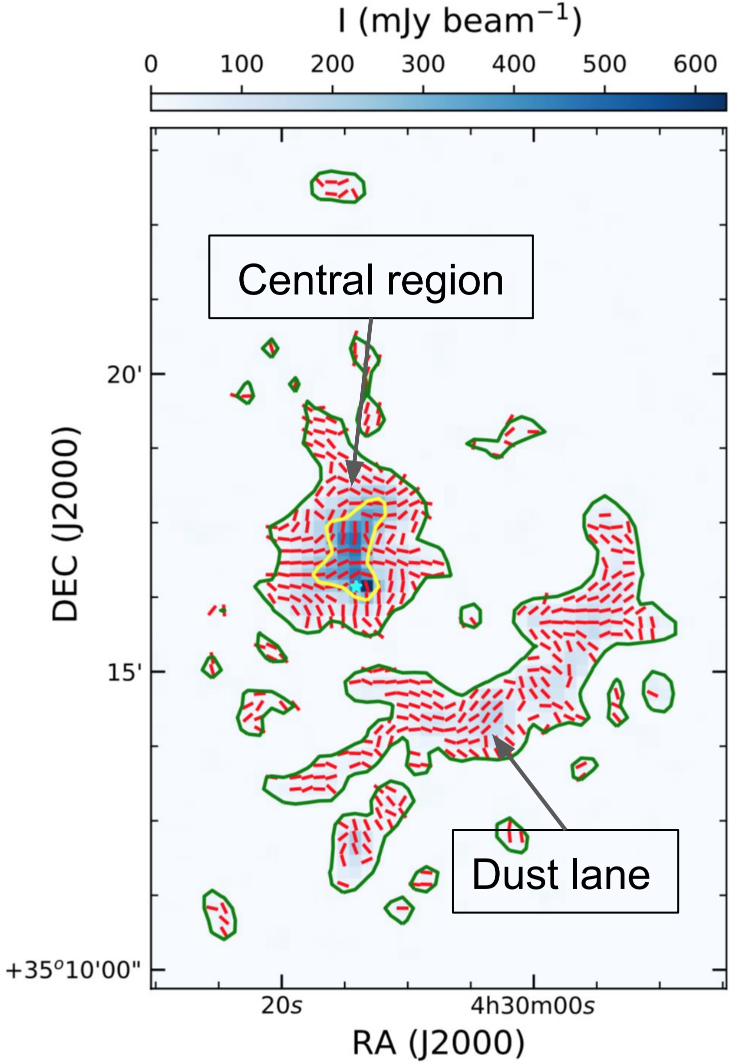
E.g. Lazarian & Hoang 2007

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

ΔV: velocity dispersion

σ_θ: polarization angle dispersion

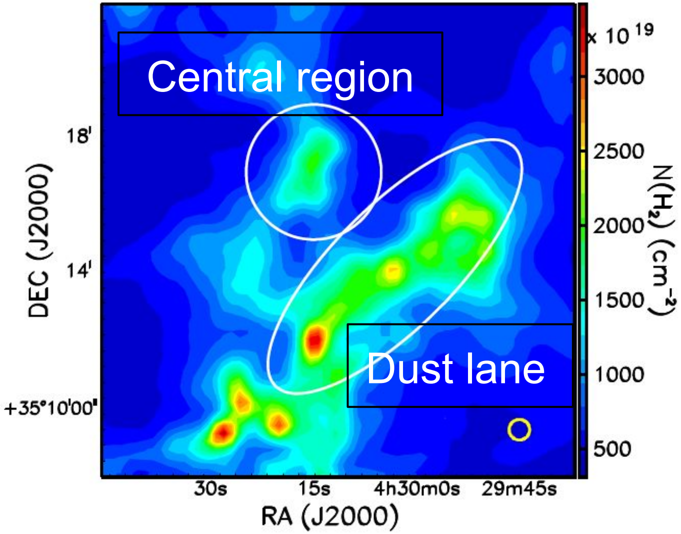
- Unsharp masking
- Structure function

$$B_{POS} \approx 9.3 \underbrace{\sqrt{n(H_2)}}_{\sim \text{gas density}} \underbrace{\frac{\Delta V}{\sigma_\theta}}_{\sim \text{Alfven velocity}}$$

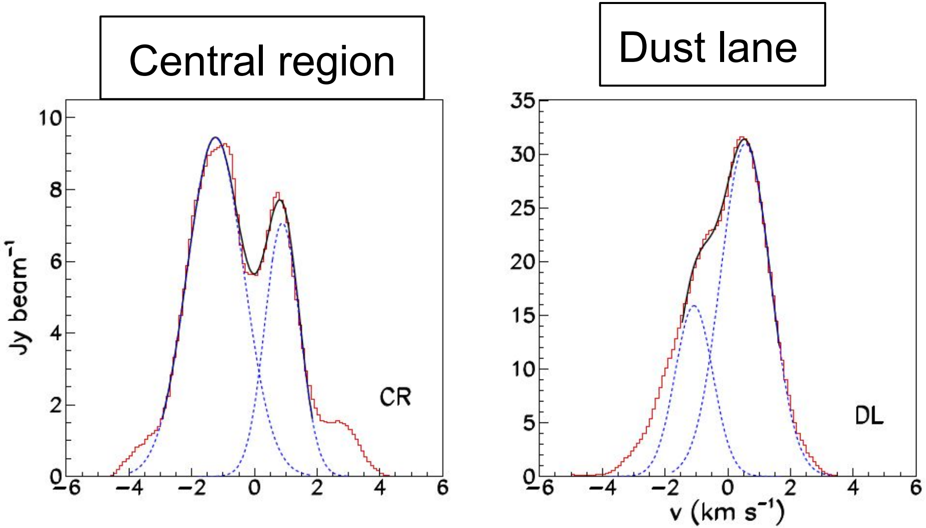
(Crutcher 2004)

$n(H_2)$: volume density
($N(H_2)$ Herschel)

ΔV: velocity dispersion
(CO(3-2) HARP/JCMT)

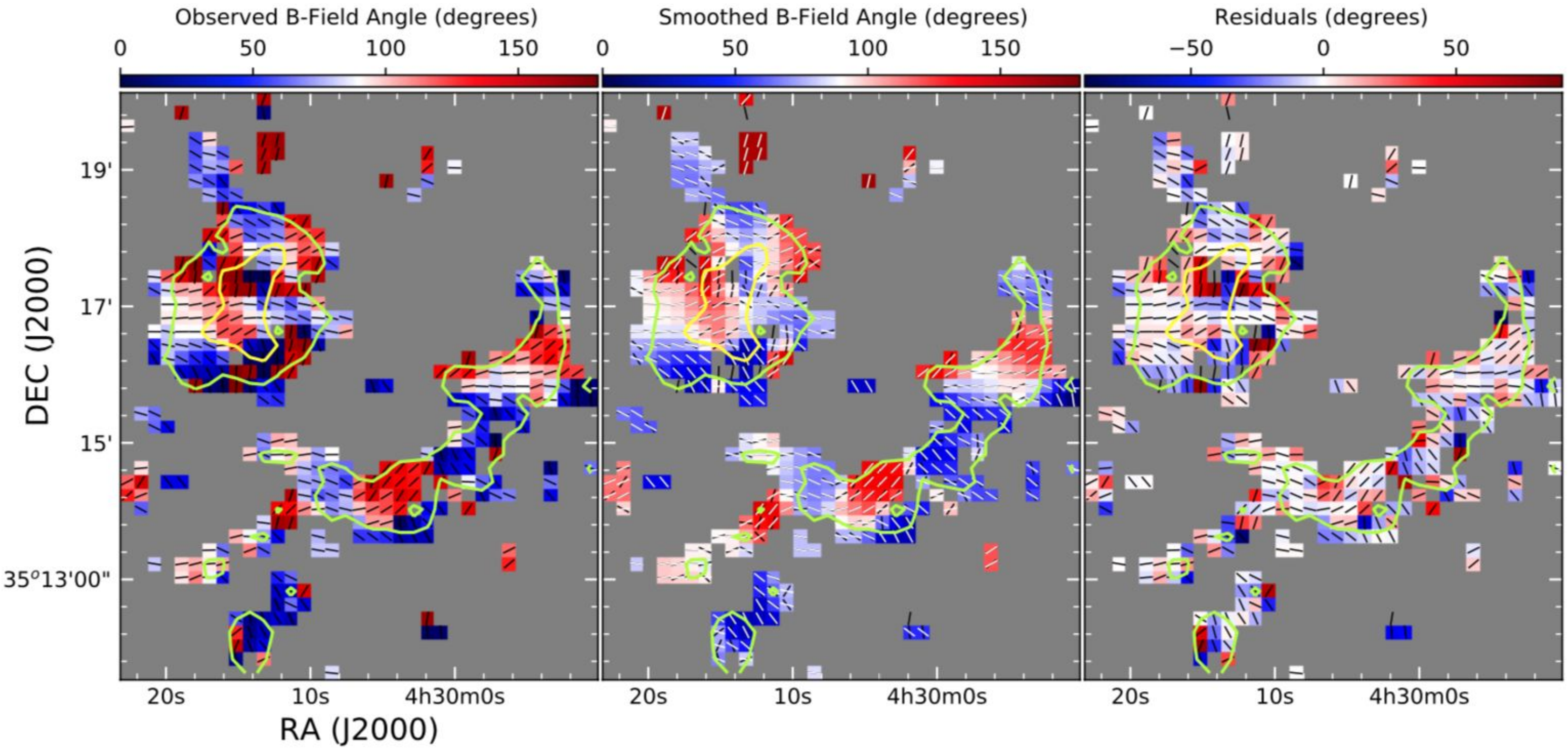


aHerschel column density map



JCMT/HARP CO(3−2) integrated spectra

Polarization angle dispersion: Unsharp masking method (Pattle+2017)



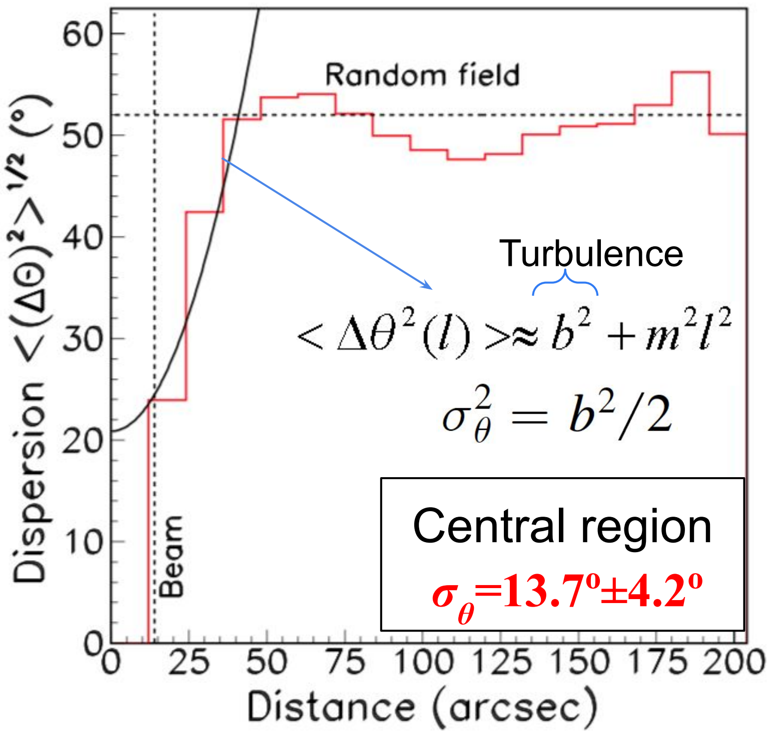
θ_{meas}

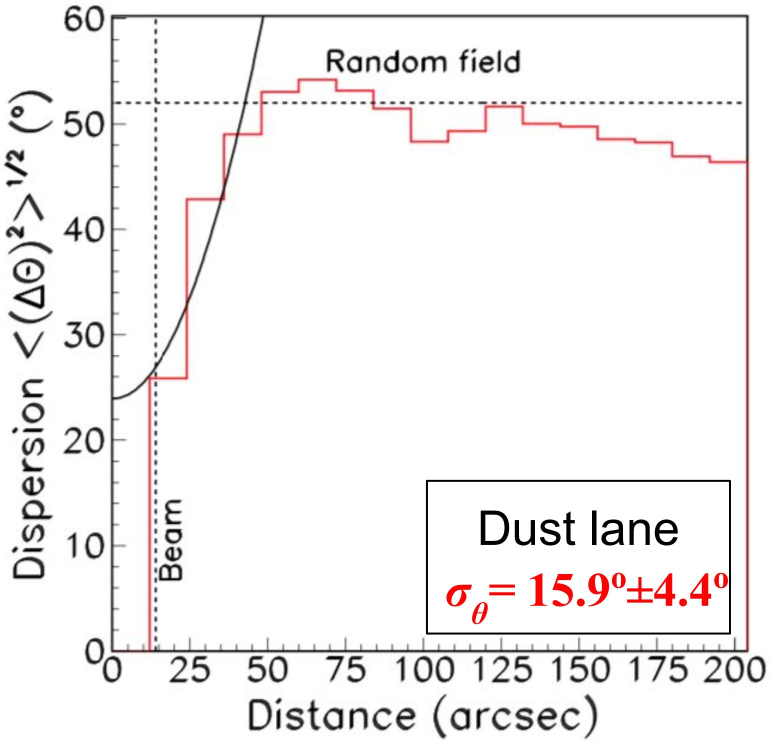
$<\theta>$ of (3x3) box

$\Delta\theta = \theta_{meas} - <\theta>$

=> **angle dispersion σ_θ**

Polarization angle dispersion: Structure function method (Hildebrand+2009)





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

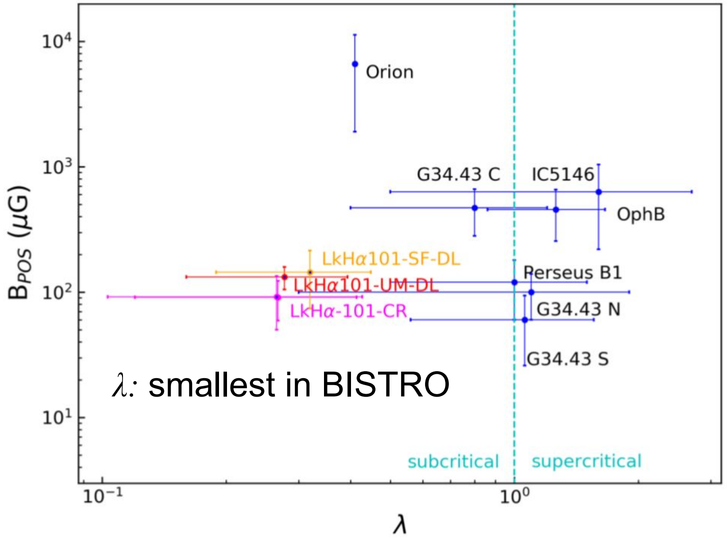
Regions are **subcritical**

=> the fields are strong enough to resist gravitational collapse

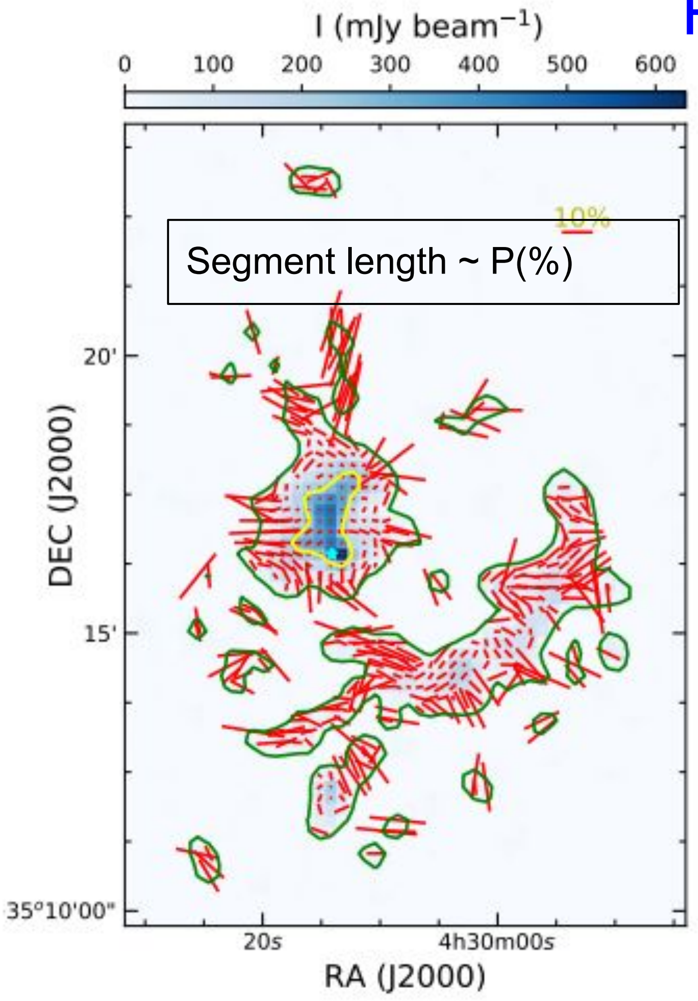
=> support the low star forming efficiency found in Auriga-California

Results

		Central region	Dust lane
Unsharp Masking	B_{POS} (μG)	91±32	132±27
	λ	0.27±0.15	0.28±0.12
Structure Function	B_{POS} (μG)	92±42	144±36
	λ	0.27±0.16	0.32±0.15



Polarization hole

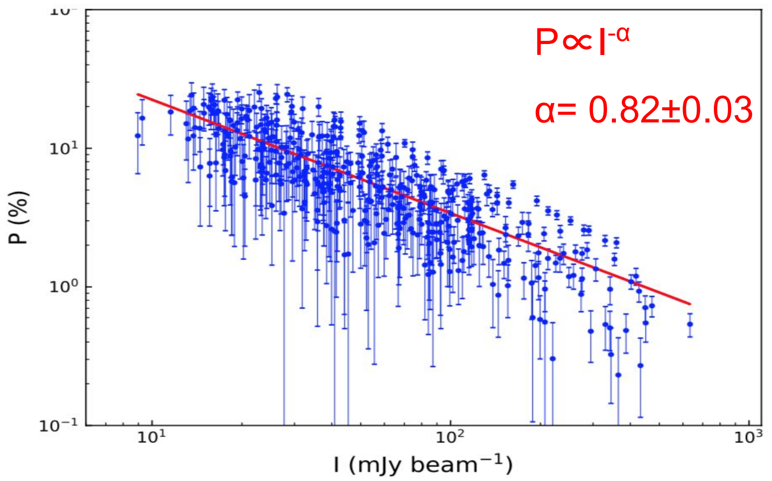


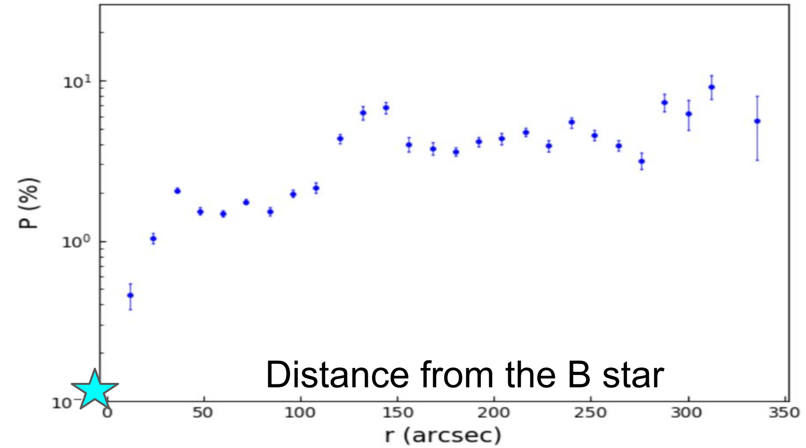
Causes (?)

B-field tangling

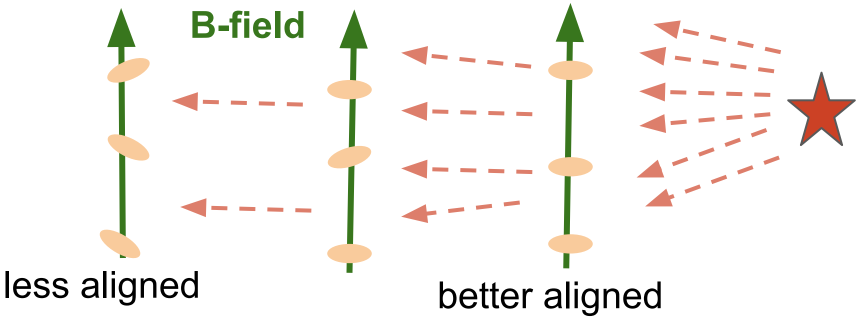
or/and

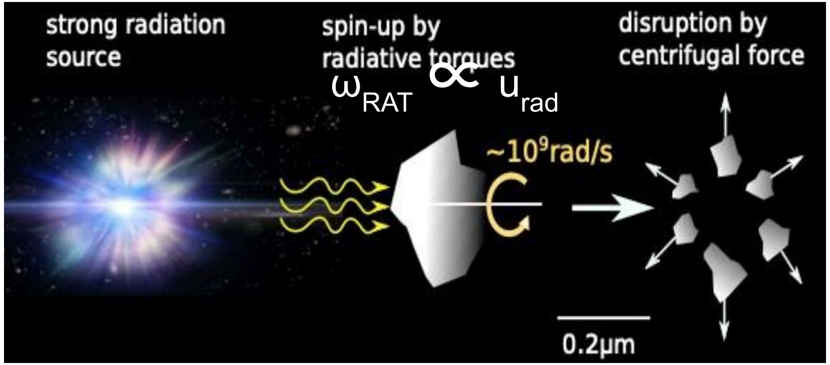
Radiative Torque Disruption (RATD)





RAdiative Torque Alignment (RATA) vs RAdiative Torque Disruption (RATD)

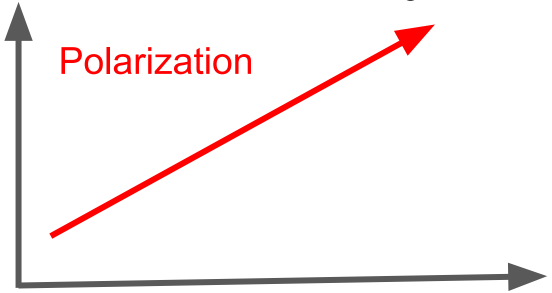




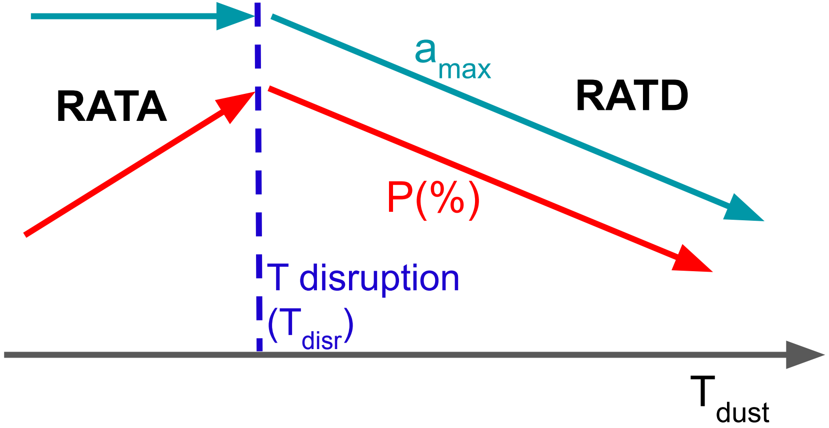
RATA prediction:
P (%) increases with increasing T_{dust}

RATD prediction: Hoang, Tram + 2019
P (%) increases and then decreases with increasing T_{dust}

E.g. Lazarian & Hoang 2007



Radiation strength ~ Dust temperature (T_{dust})



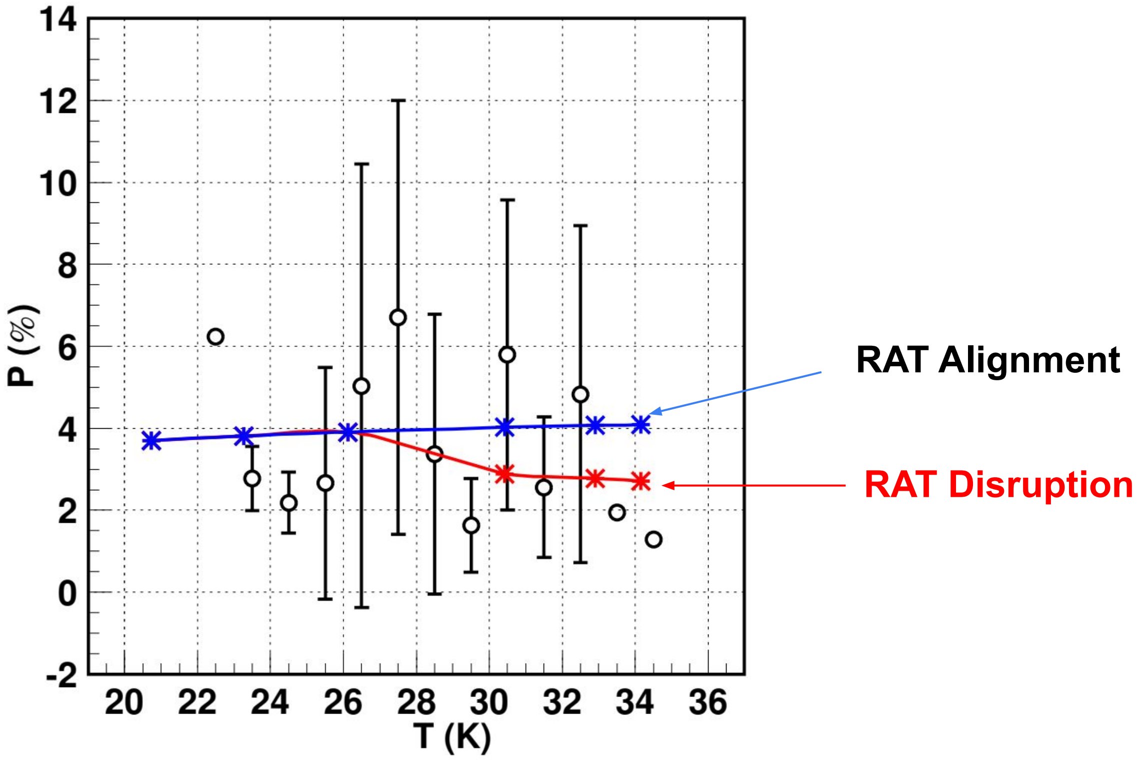
LkHα 101: Central region

Input parameters for the model

Dust	S_{max}	10^7 erg cm^{-3}
	Axial ratio	0.333
	Volume density of the dust grains, ρ	3 g cm^{-3}
	a_{min}	10 A^0
	a_{max}	1 μm
	Size distribution power index, β	-3.5 or -4
Gas	T_{gas}	20 K
	n_H	1.22 10^4 cm^{-3}
Ambiance	*Mean wavelength, λ*	0.45 μm
	Anisotropy degree of radiation field, γ	1

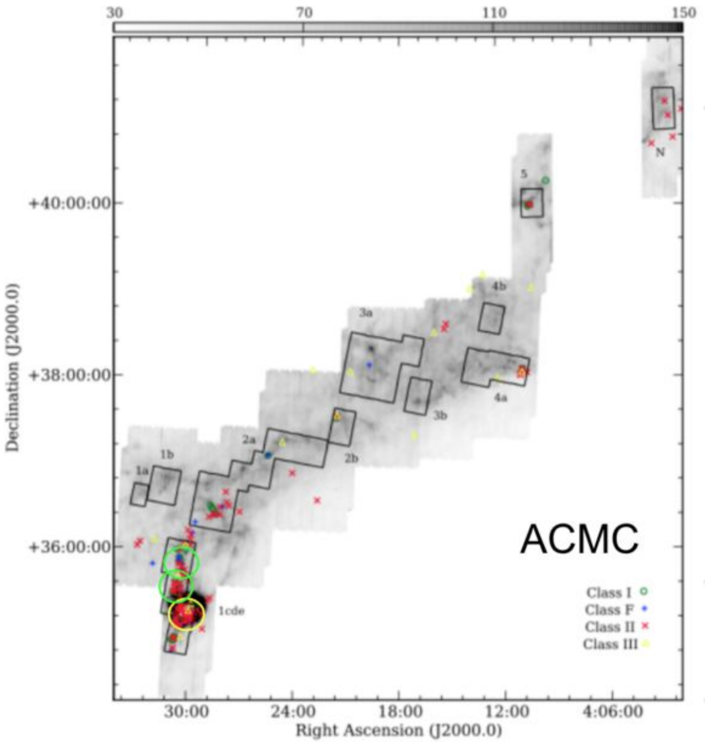
Lee+ 2020

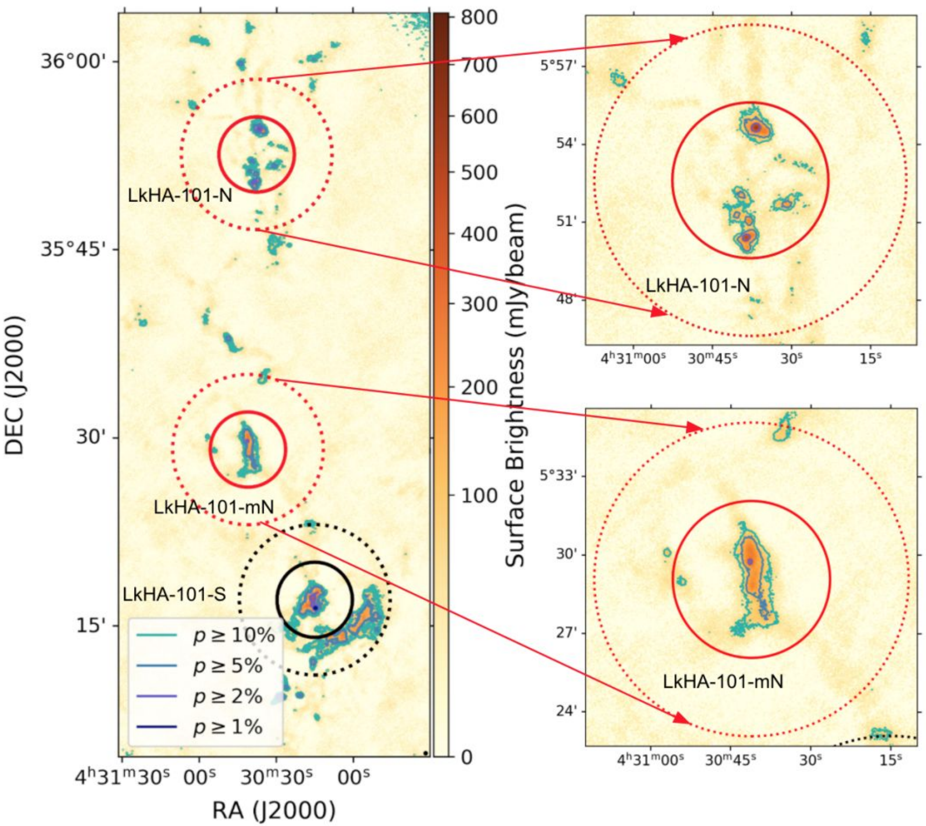
P(%) vs. T_{dust}(K) RAT predictions



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 **λ≈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!