Magnetic fields in Cepheus OB3 cloud complex

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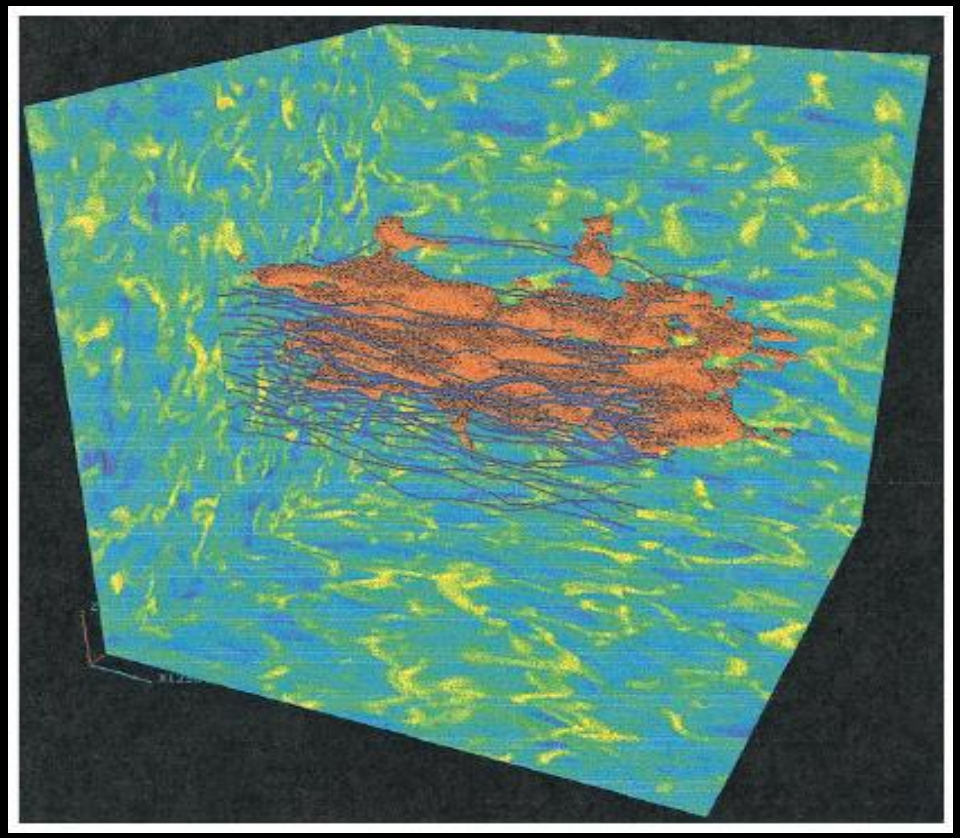
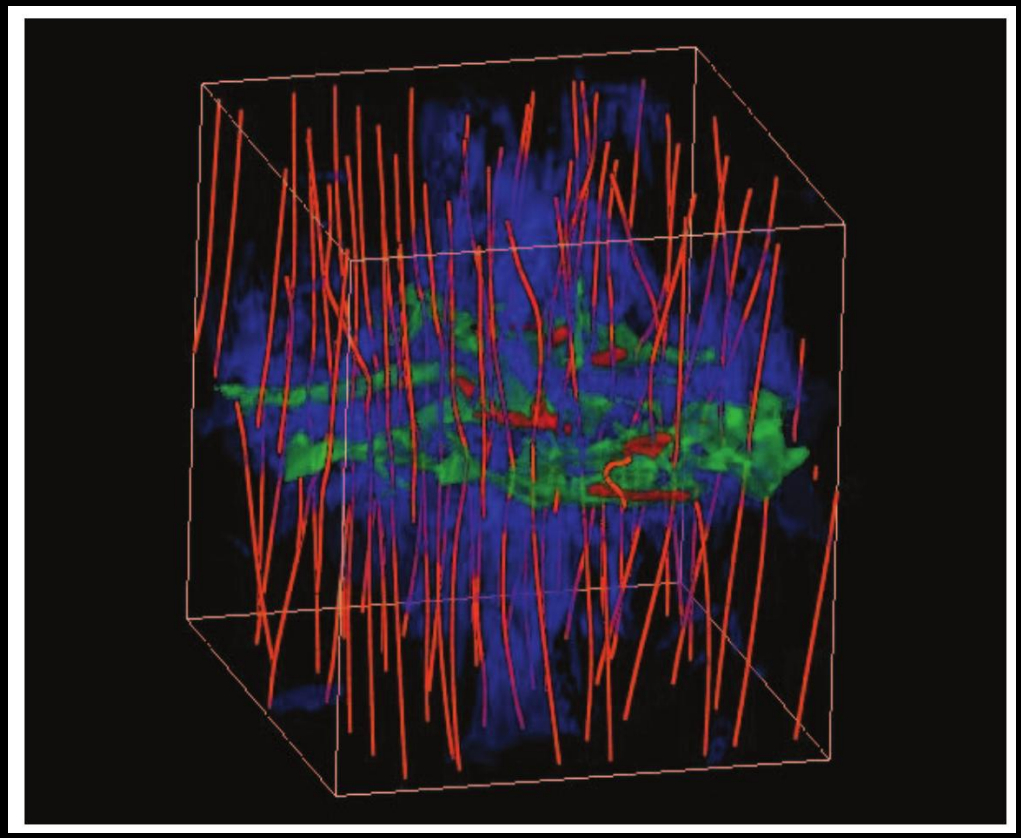
Relative orientation between filament and magnetic fields: strong B-fields



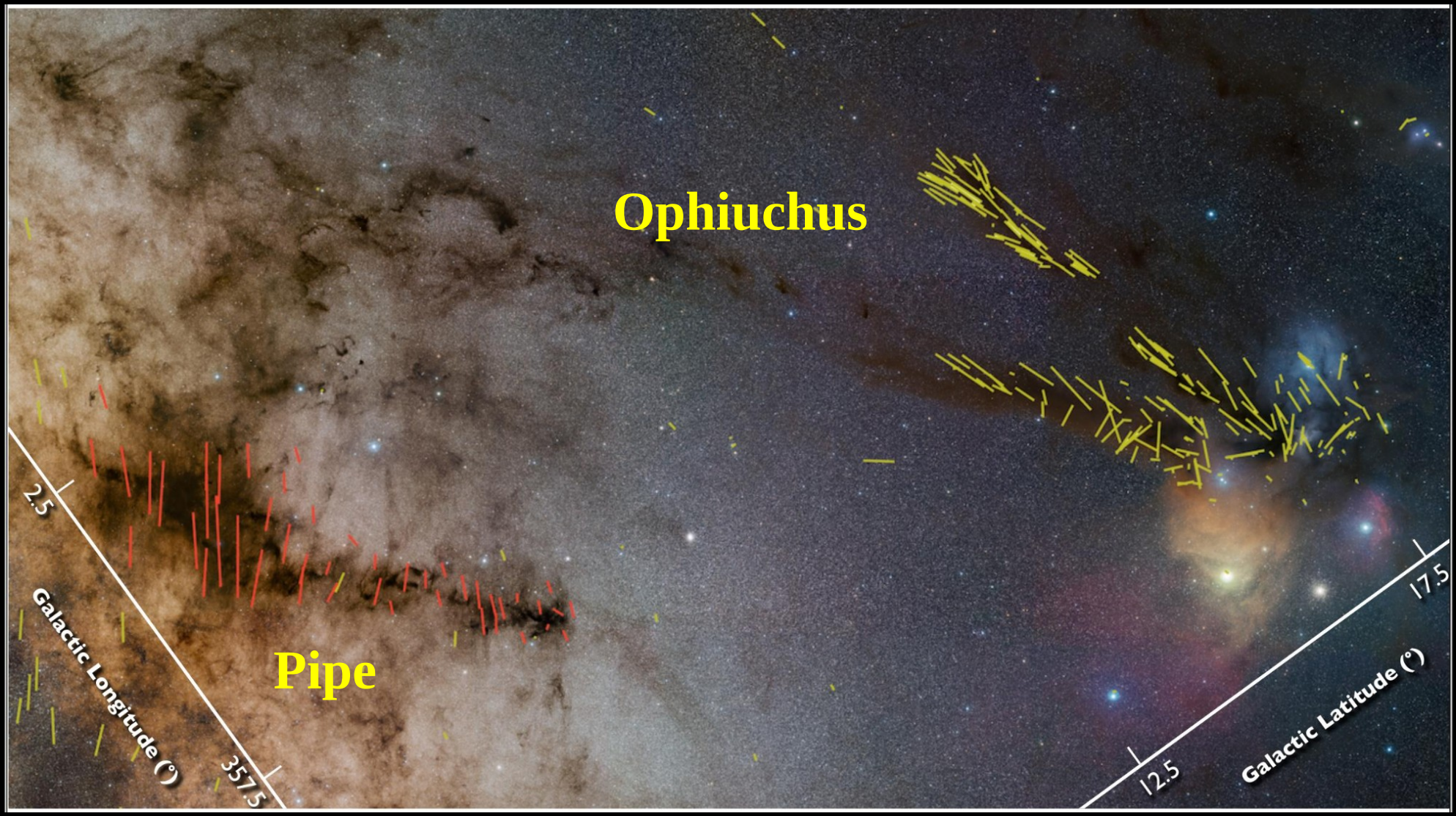
Turbulence dominates over gravity
=> turbulence extends cloud along the B-fields

Stone+ (1998)

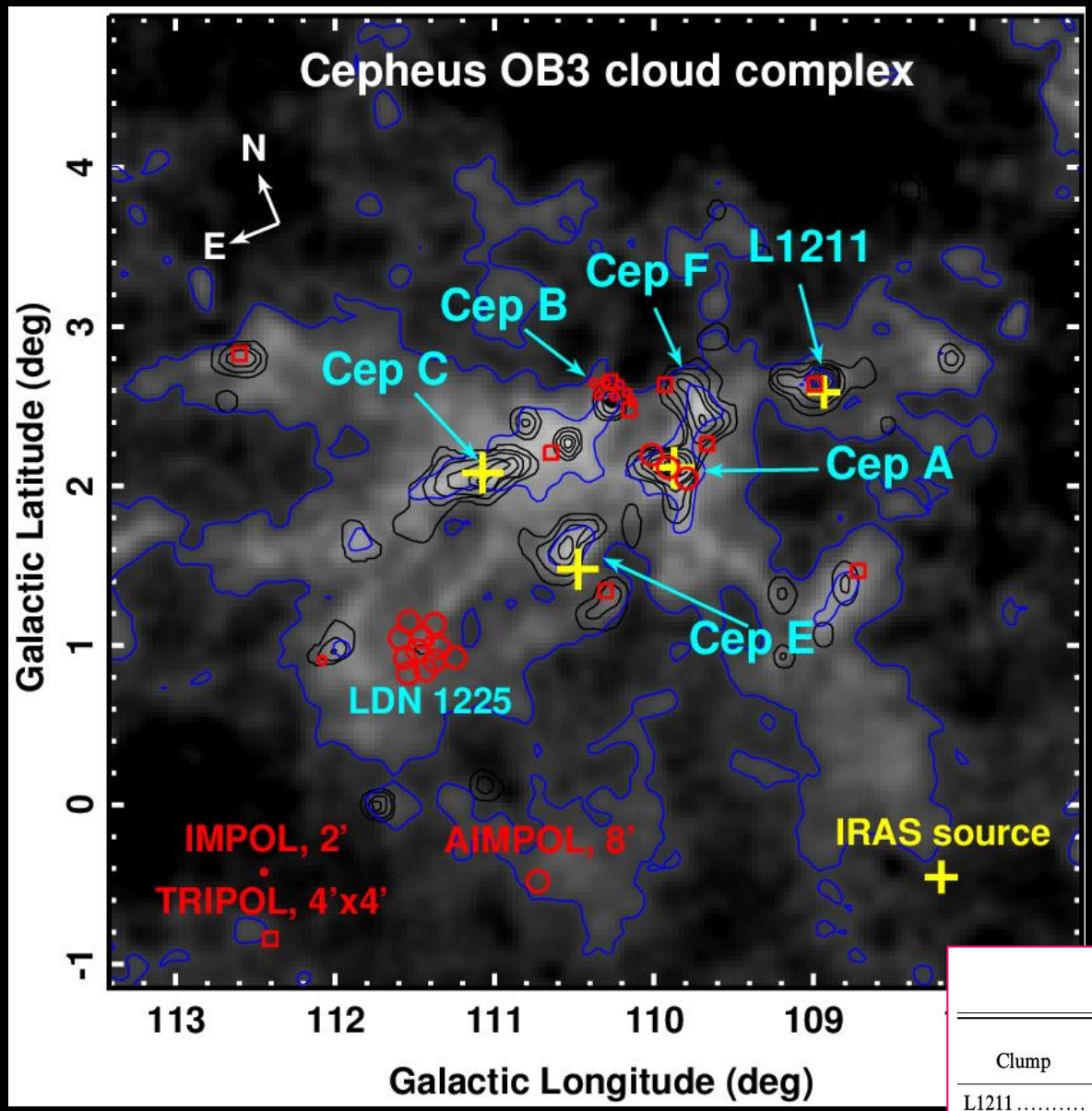


Gravity dominates turbulence
cloud contracts parallel to the B-fields

Nakamura & Li (2008; 2011)



B-fields vs filamentary cloud structure – Ophiuchu-Pipe region
(see Li+ 2017)



Black contours: 13CO map (Yonekura+ 1997)
Blue contours: Av=2, 4 mag
Background image: extinction map (Dobashi+ 2005)
Clumps based on C18O data (Yu+ 1996)

Cepheus OB3 cloud complex
107 < l < 114 deg;
-2 < b < 5 deg)
Distance: ~400 - ~600 pc

13CO map (Yonekura+ 1997)
– Vlsr ~ - 10 km/s
– foreground component
– at ~ -5 km/s
– distance 300 pc

Various parameters of the clumps

TABLE 2

PHYSICAL PARAMETERS OF CLOUD CORES IN CEPHEUS OB3

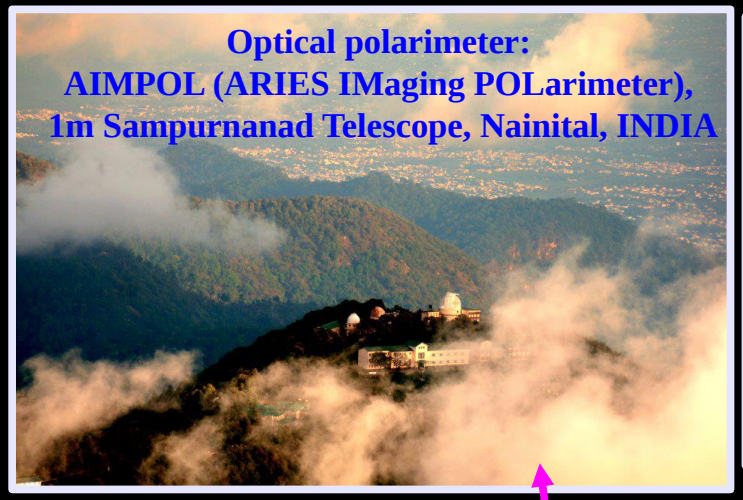
Clump	Size (pc)	T_{ex} (K)	$\tau(C^{18}O)$	$N(C^{18}O)$ (10^{15} cm^{-2})	$N(H_2)$ (10^{22} cm^{-2})	$n(H_2)$ (10^3 cm^{-3})	M(LTE) ($M_\odot$)	M(vir) ($M_\odot$)
L1211	1.9	17	0.100	2.6	1.5	2.6	610	490
Cep A	1.2	22	0.055	4.6	2.7	7.6	410	1200
Cep F	1.4	12	0.124	1.4	0.8	1.9	180	240
Cep B	0.7	33	0.025	2.1	1.2	6.0	62	150
Cep E	1.5	17	0.064	1.7	1.0	2.1	250	390
Cep C (a)	1.2	17	0.037	1.4	0.8	2.2	120	610
Cep C (b)	1.9	17	0.099	3.6	2.1	3.8	820	970
Cep C (c)	1.0	17	0.089	3.0	1.8	6.1	180	430

Table 2 of Yu+ (1996)

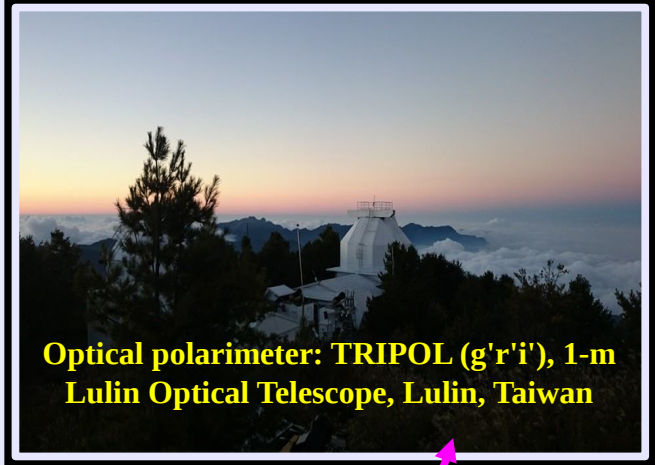
Data

- **AIMPOL,R-band, 8’** (FOV)
- **IMPOL, R-band, 2’**
- **TRIPOL, r’-band, 4’**

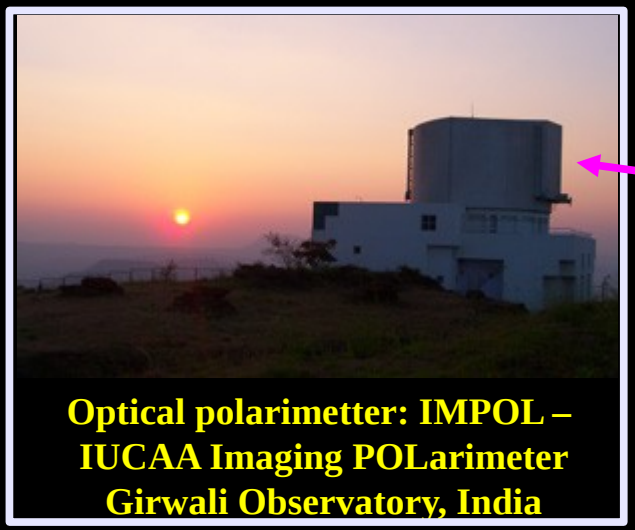
- archival polarization data (Heiles 2000)
- Optical photometry (BVRI-bands)
- 2MASS (JHKs-bands)



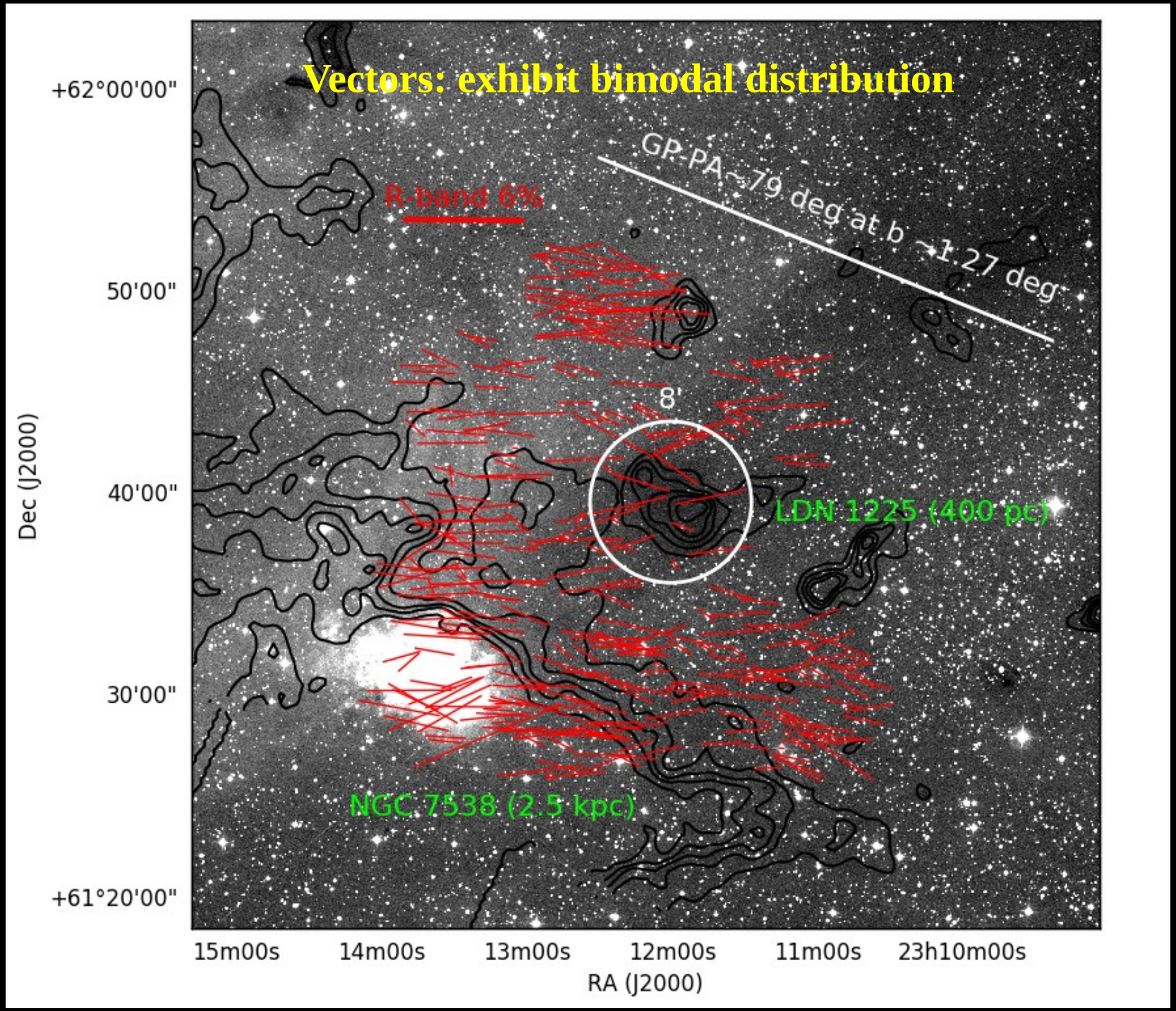
Optical polarimeter: AIMPOL (ARIES IMaging POLarimeter), 1m Sampurnanad Telescope, Nainital, INDIA



Optical polarimeter: TRIPOL (g'r'i'), 1-m Lulin Optical Telescope, Lulin, Taiwan



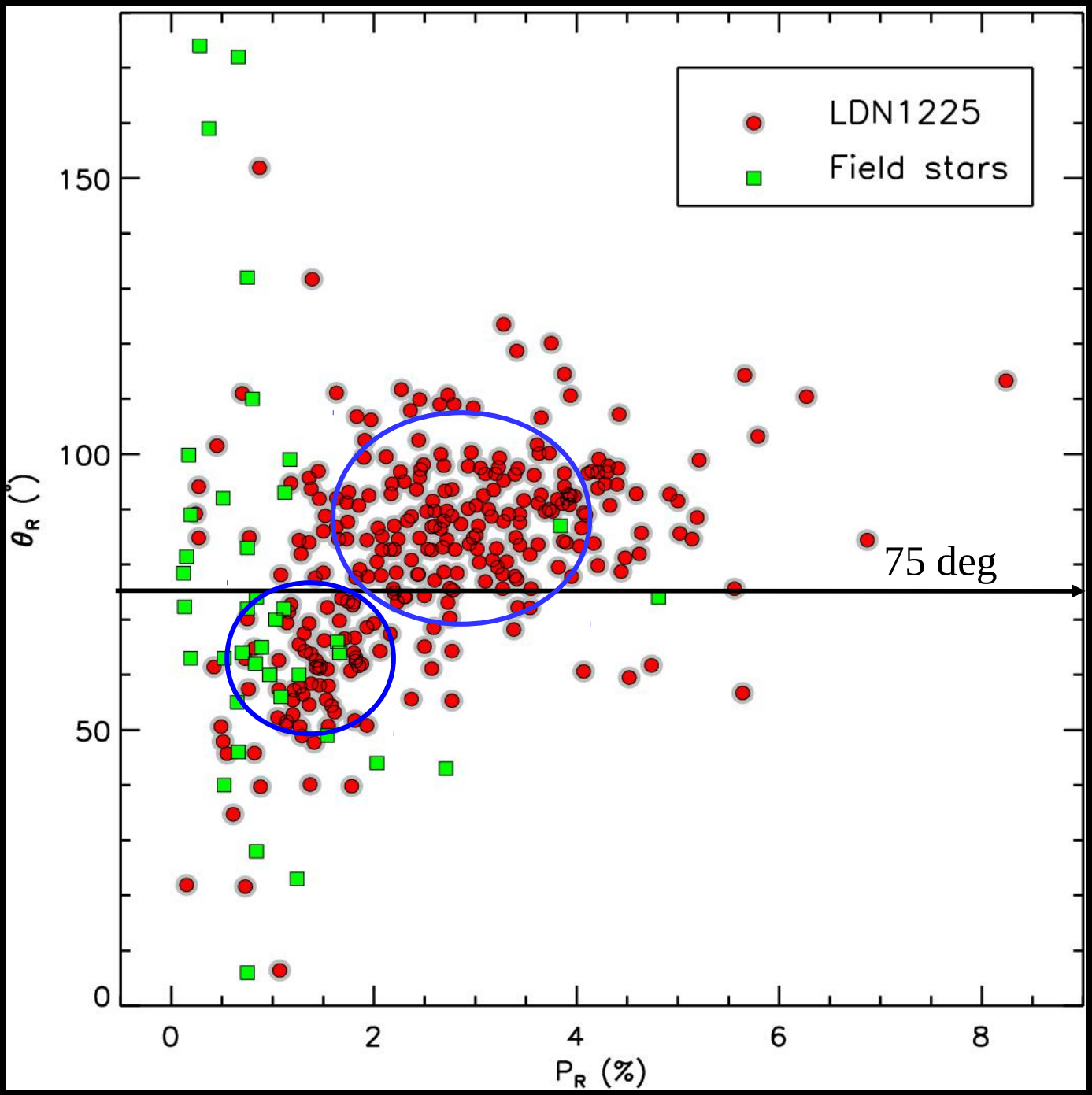
Optical polarimetter: IMPOL – IUCAA Imaging POLarimeter Girwali Observatory, India



R-band polarization vectors of ~ 300 stars on DSS R-band image

Contours: Herschel 500 um dust emission

P vs PA for stars observed towards LDN 1225

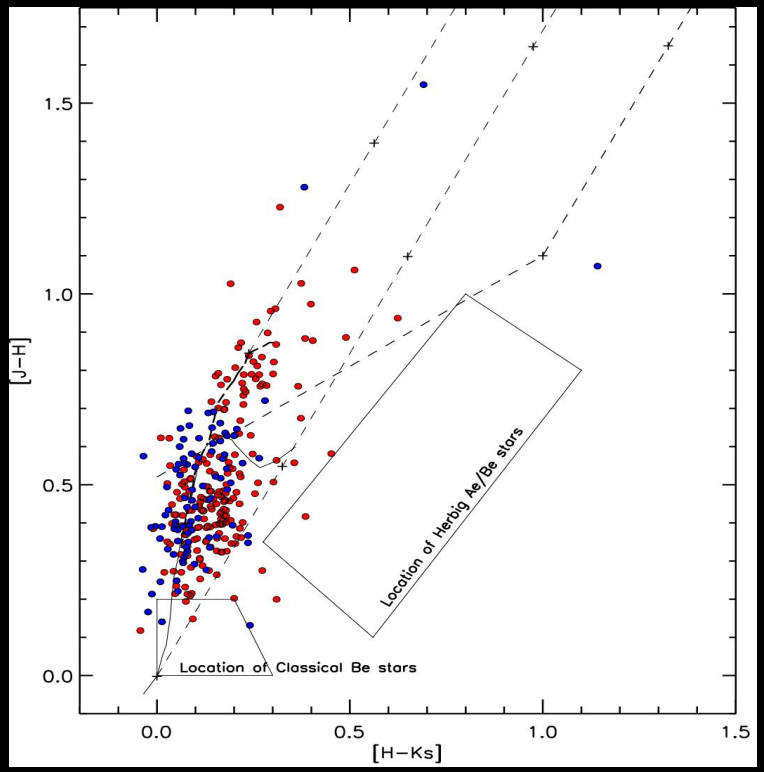


Separation of foreground and background stars

Green: Field stars (Heiles 2000) – 10 deg radius

GP: 79 deg toward LDN 1225

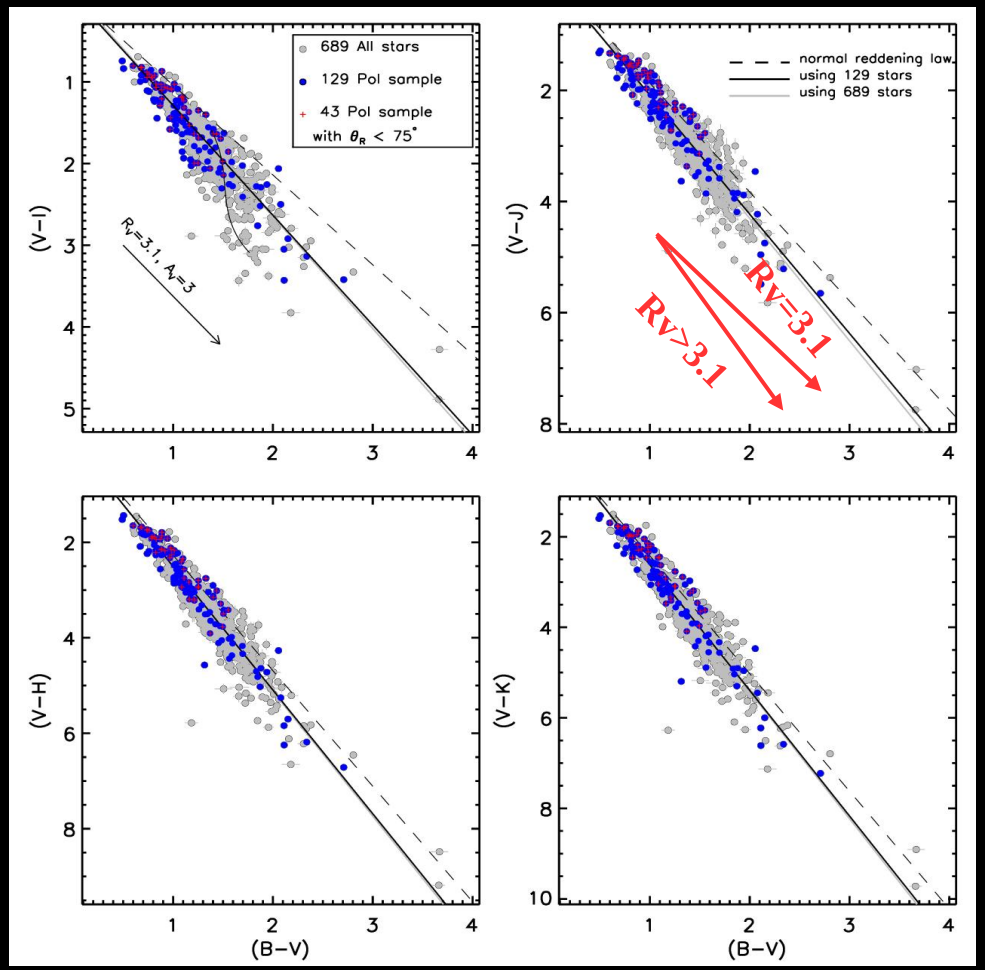
Two populations are present



NIR color-color diagram.

Blue: foreground stars with PA < 75 deg

Red: background stars with PA > 75 deg

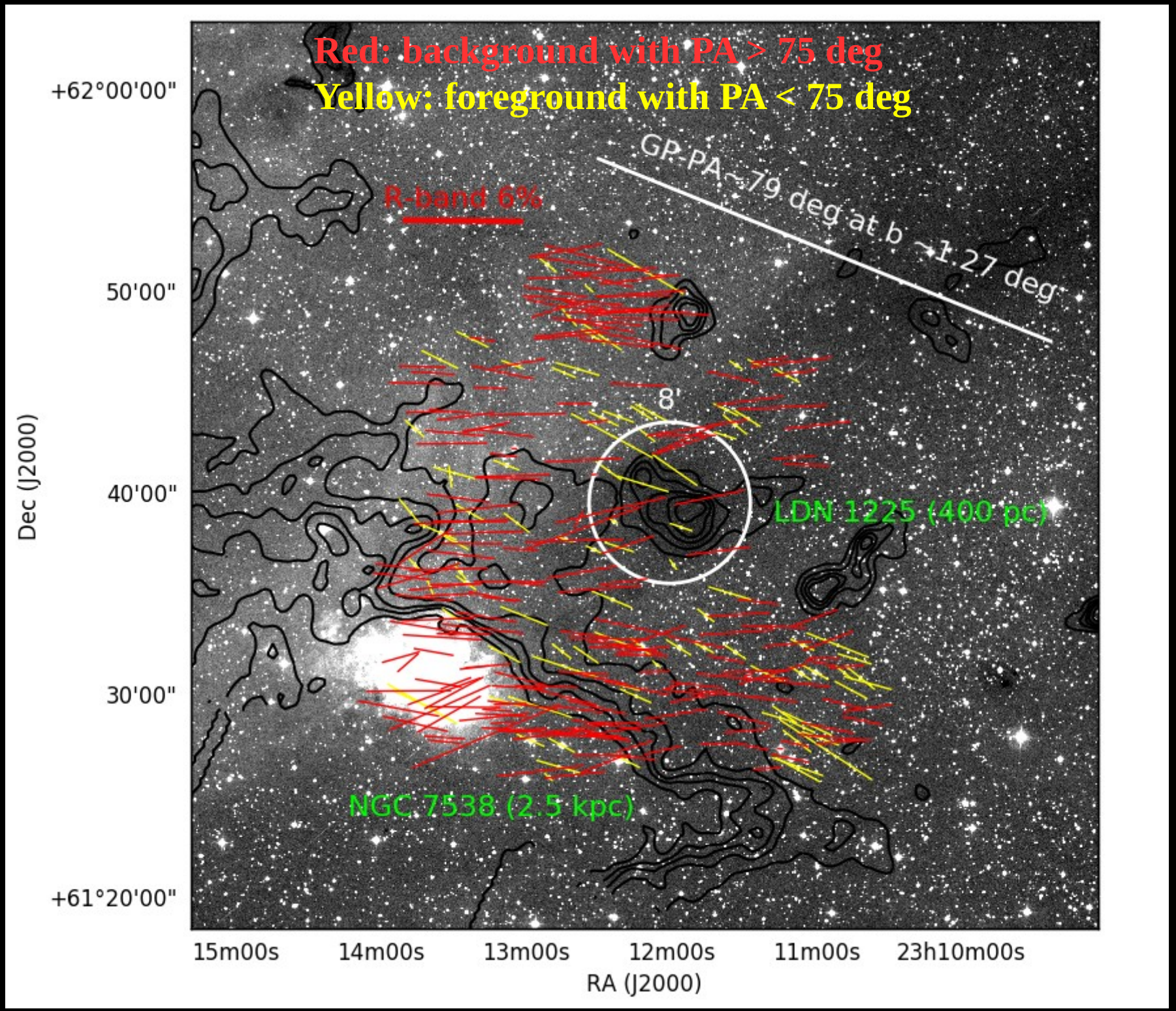


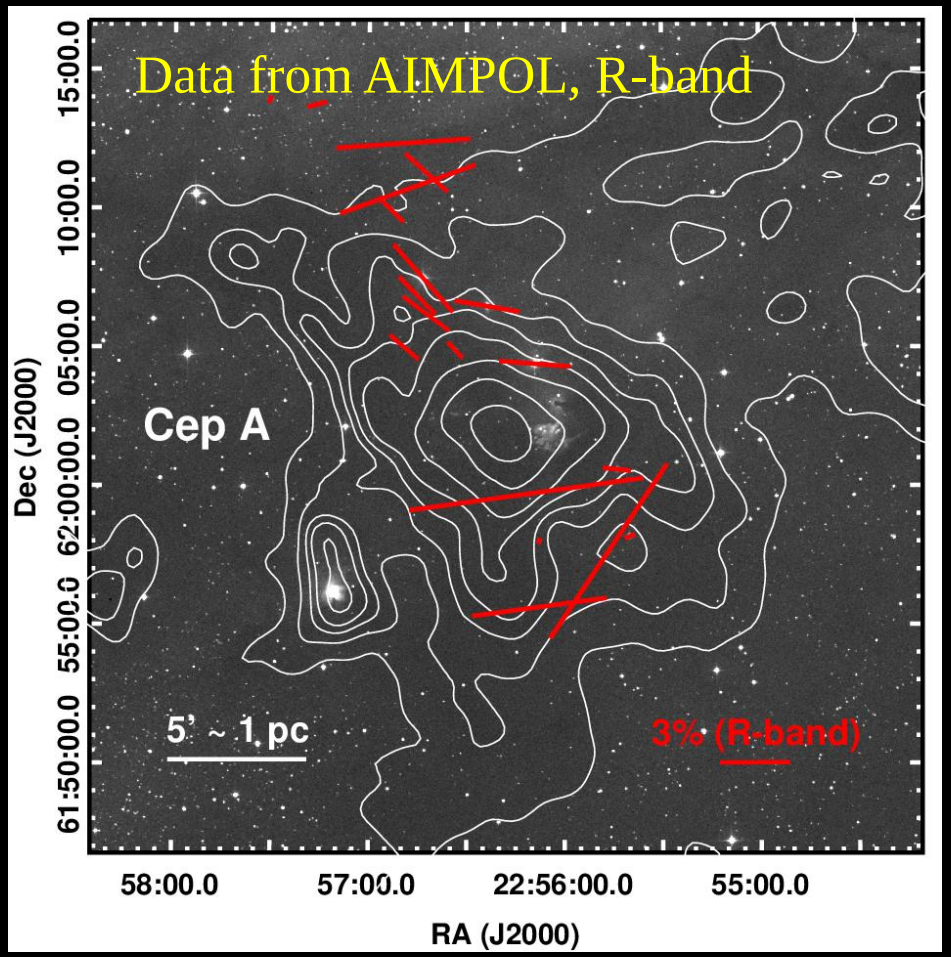
Color-color diagrams:

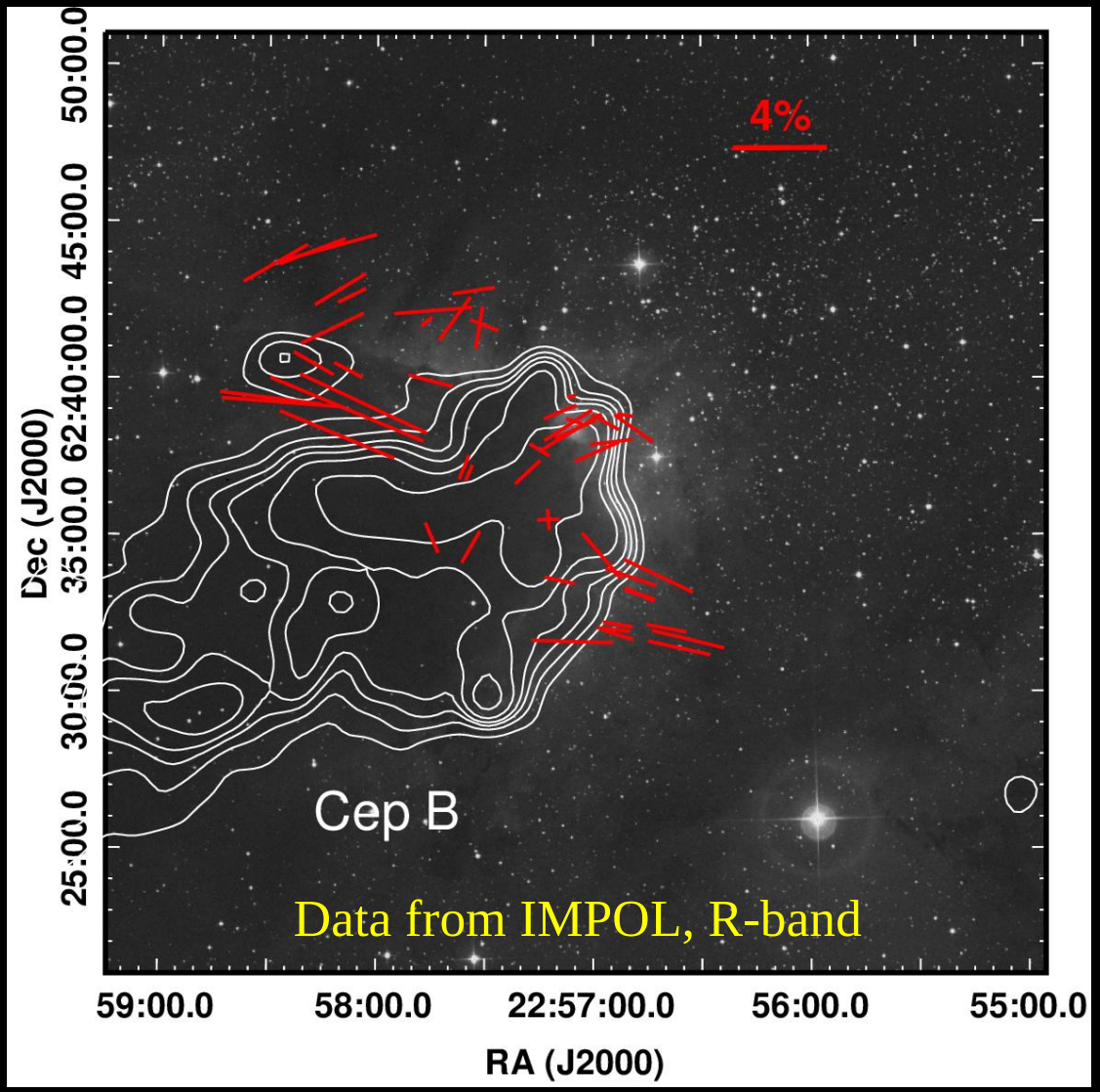
Color–color combination	m_{normal}
$(B-V)/(V-I)$	−1.10
$(B-V)/(V-J)$	−1.96
$(B-V)/(V-H)$	−2.42
$(B-V)/(V-K)$	−2.60

$$R_{cloud} = \frac{m_{cloud}}{m_{normal}} R_{normal}$$

Rnormal=Rv=3.1

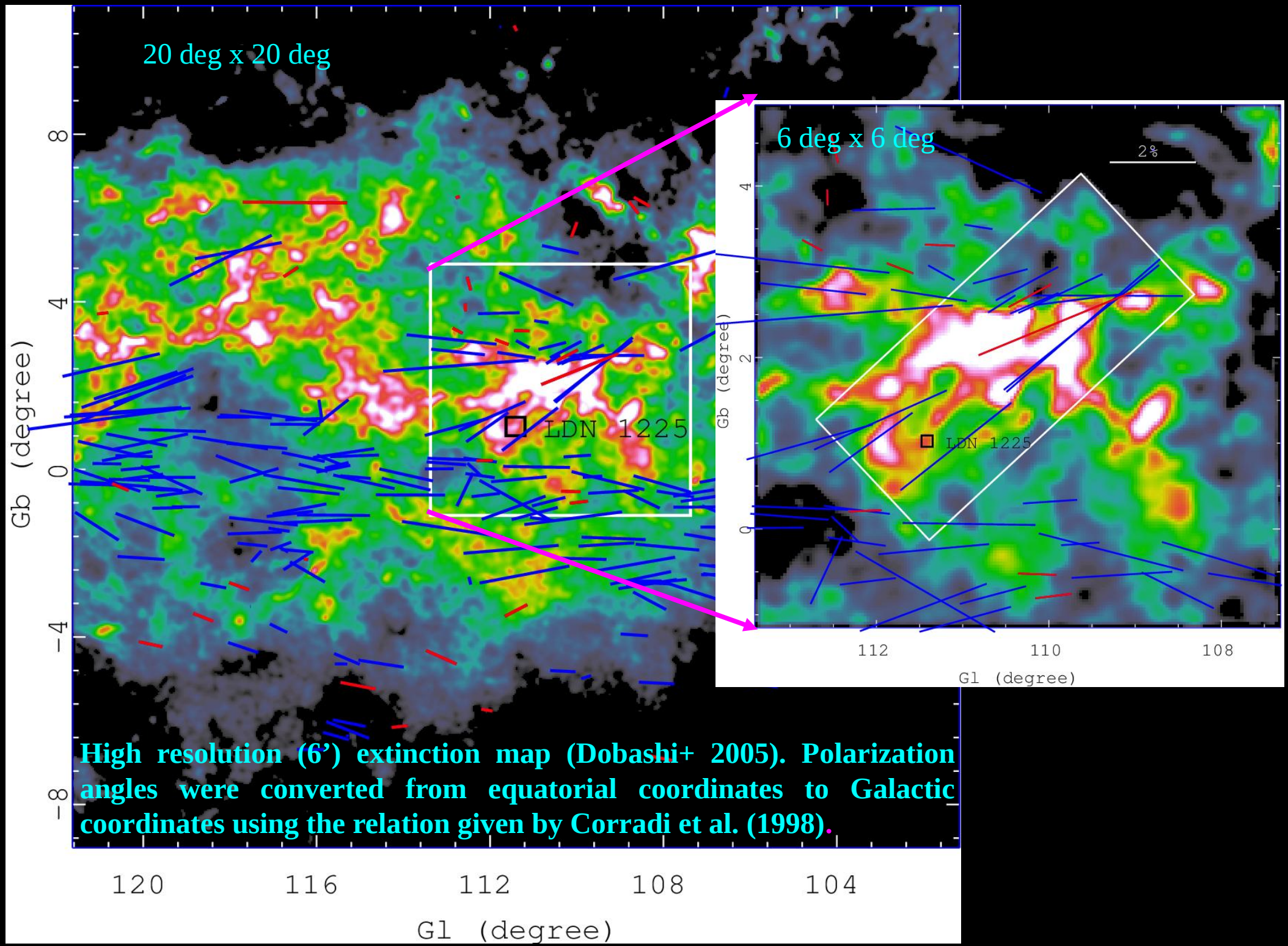

Red: background with PA > 75 deg
Yellow: foreground with PA < 75 deg
GP-PA ~ 79 deg at b ~ 1.27 deg
R-band 6%
8'
LDN 1225 (400 pc)
NGC 7538 (2.5 kpc)
+62°00'00"
50'00"
40'00"
30'00"
+61°20'00"
Dec (J2000)
15m00s
14m00s
13m00s
12m00s
11m00s
23h10m00s
RA (J2000)



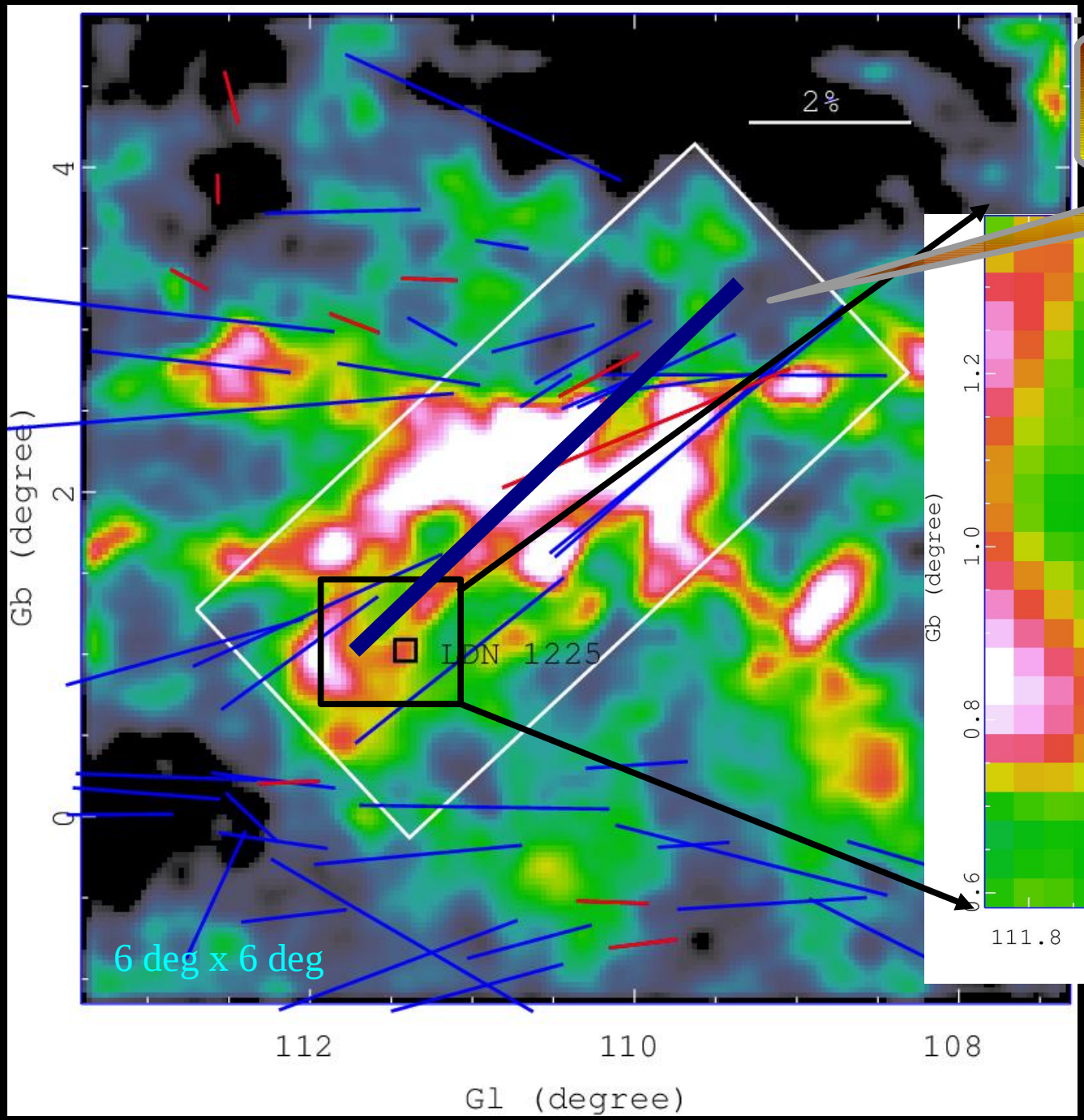


Bimodal distribution of P and PA towards Cep A and Cep B

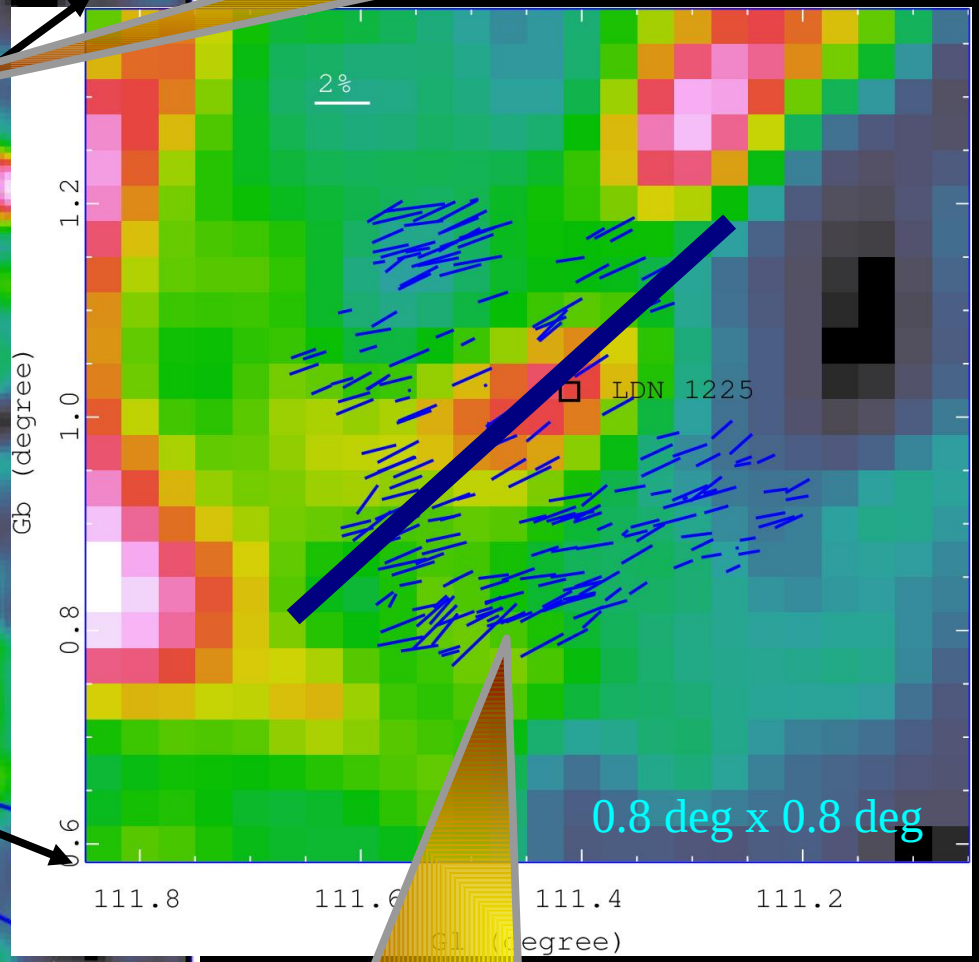
Contours:
Herschel 500um dust emission



High resolution (6') extinction map (Dobashi+ 2005). Polarization angles were converted from equatorial coordinates to Galactic coordinates using the relation given by Corradi et al. (1998).

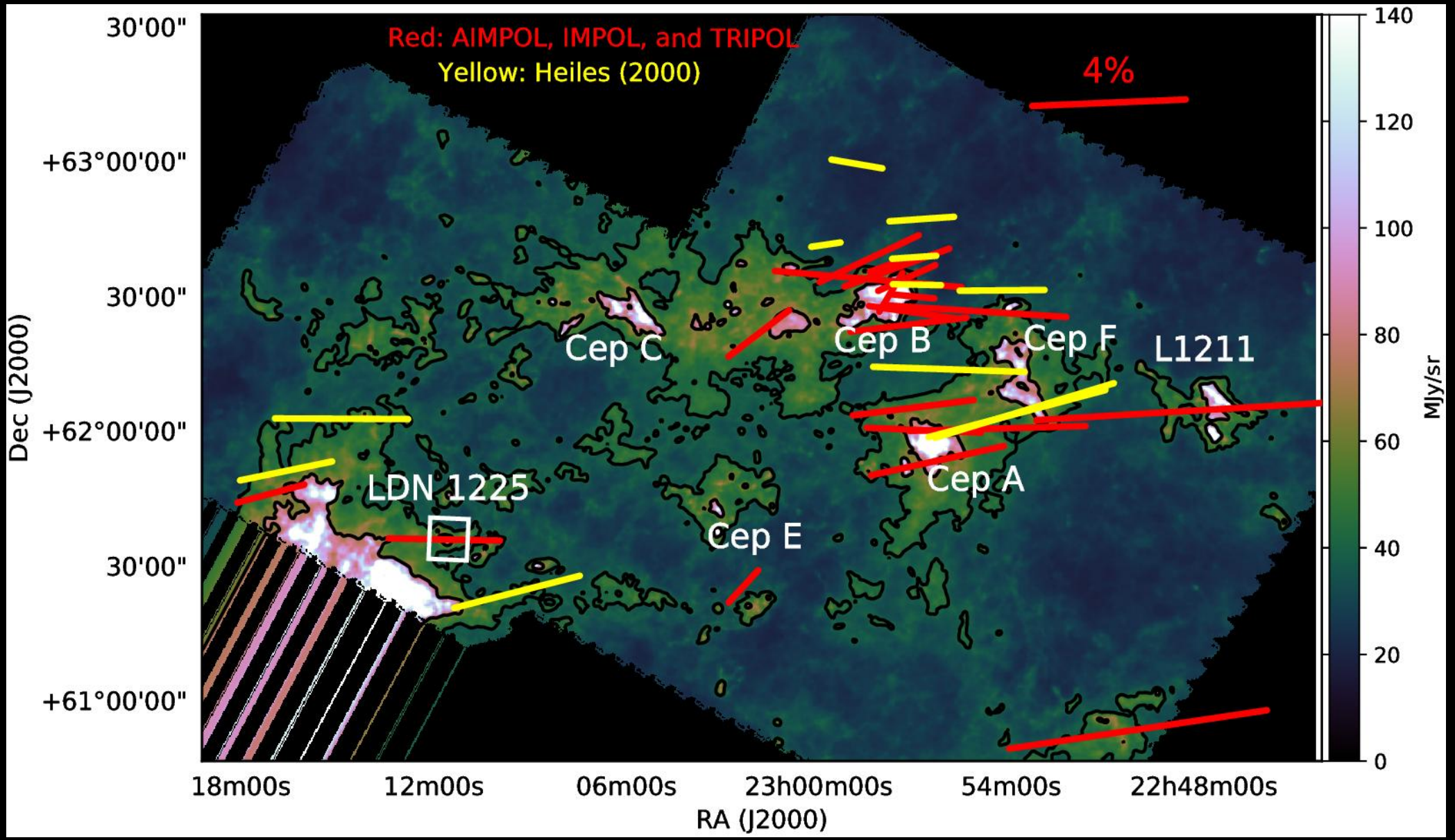


14 stars from Heiles (2000) catalog:
Guassian Mean P: 2.55+/-1.38 %
PA: 116+/- 12 deg

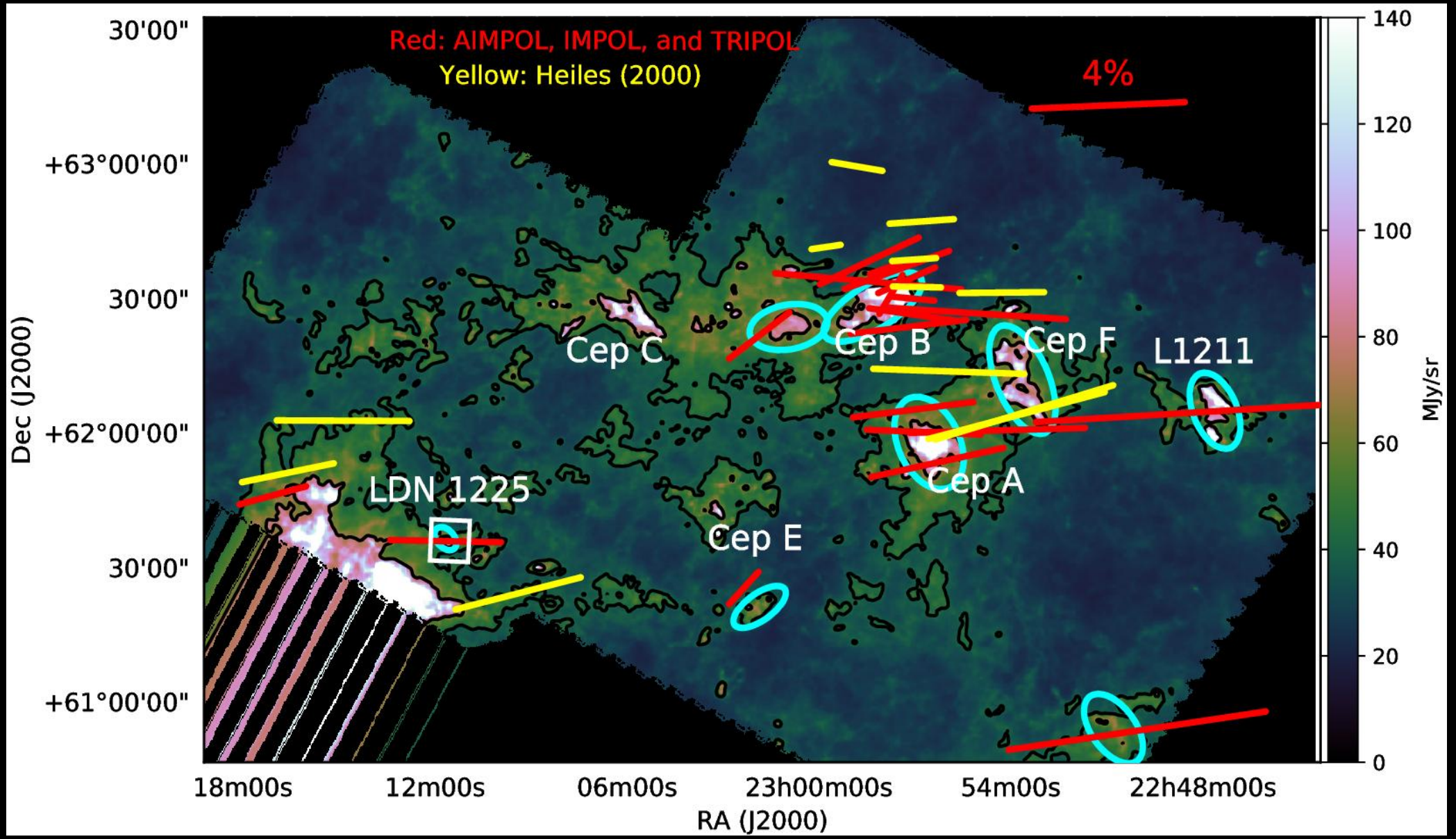


202 stars observed in R-band:
Guassian Mean P: 2.97+/-1.15 %
PA: 112+/- 10 deg

Coherence: B-field 40 pc x10 pc to 3 pc x 3 pc scale
But not with the large scale Galactic magnetic field

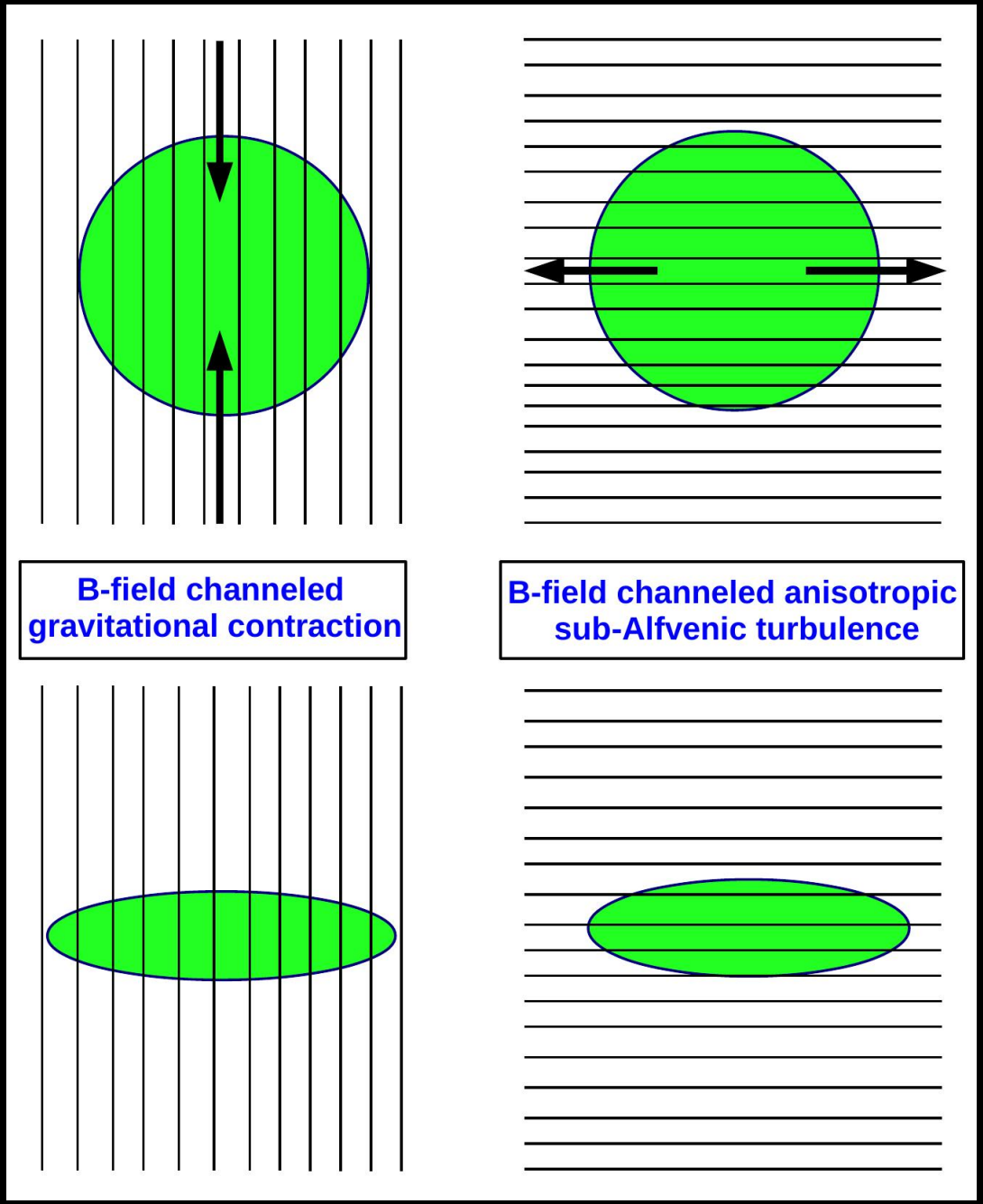


B-field structure using mean PA from AIMPOL, IMPOL and TRIPOL. Background image: Herschel 500 um map



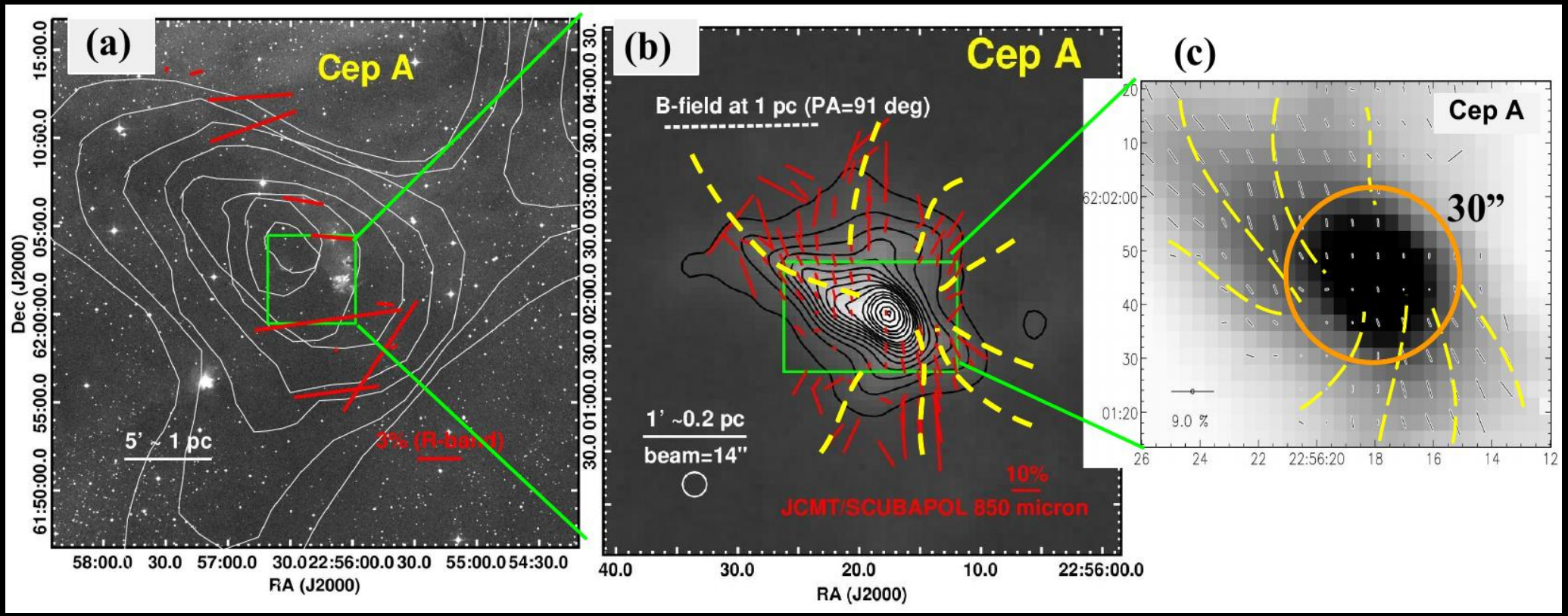
B-field structure using mean PA from AIMPOL, IMPOL and TRIPOL. Background image: Herschel 500 um map

* Magnetic fields, gravity and turbulence - result bimodal distribution
* B-fields - guide gravitational contraction - result - B-field perpendicular to the filament
* B-fields - channel sub-Alfvenic turbulence - result - B-field aligned with the cloud main axis.
* Bimodal distribution - not seen - simulations with supersonic turbulence - random cloud/field orientations



Li+ (2013)

B-fields at clump and core scales around Cep A



(a) R-band polarization => B-fields perpendicular to the clump.

(b) and (c) Sub-mm 850 um polarization (JCMT/SCUBAPOL) => spiral B-field features, cloud collapsing (Curran & Chrysostomou 2007; Matthews+ 2009)

Summary & Conclusions

- R-band polarimetry towards Cepheus OB3 cloud complex
- Foreground and background stars exhibit bimodal distribution in both P & PA.
- B-fields in Cepheus OB3 cloud aligned with the cloud structure (40 pc x 10 pc scale), but not with Galactic B-fields, while foreground B-fields follow Galactic B-fields.
- B-fields vs trubulence (sub-alfvenic) => aligned B-fields with cloud axis
- B-fields vs gravity => perpendicular B-fields wrt the cloud main axis
- Further observations NIR and sub-mm wavelengths, along with molecular line observations are essential.