Near-IR/Optical polarimetry around the low-mass star-forming region NGC 1333 IRAS 4A

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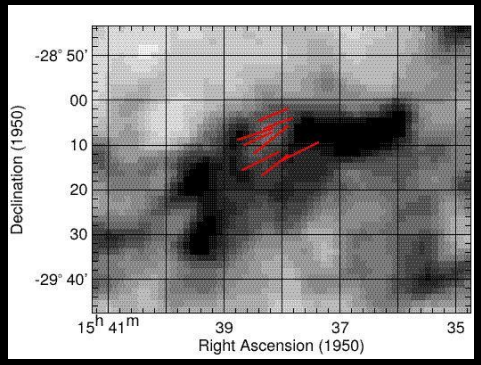
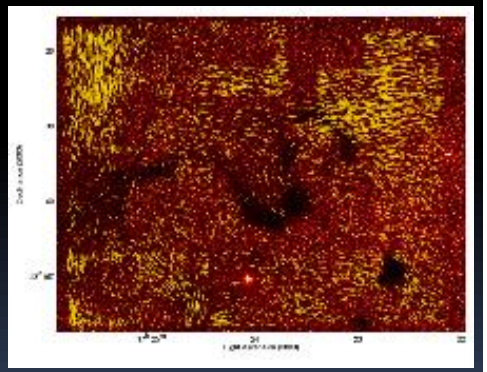
Outline

- Dynamical evolution of molecular clouds:
  - Clouds at distinct states (Lupus, Pipe, NGC 1333);
- NGC 1333:
  - Young star-forming region (~ 1 Myr);
- Motivation:
  - Hourglass *B*-field of NGC 1333 IRAS 4A;
- Near-IR polarimetry + optical polarimetry:
  - cloud *B*-field around IRAS 4A
- Results and discussion

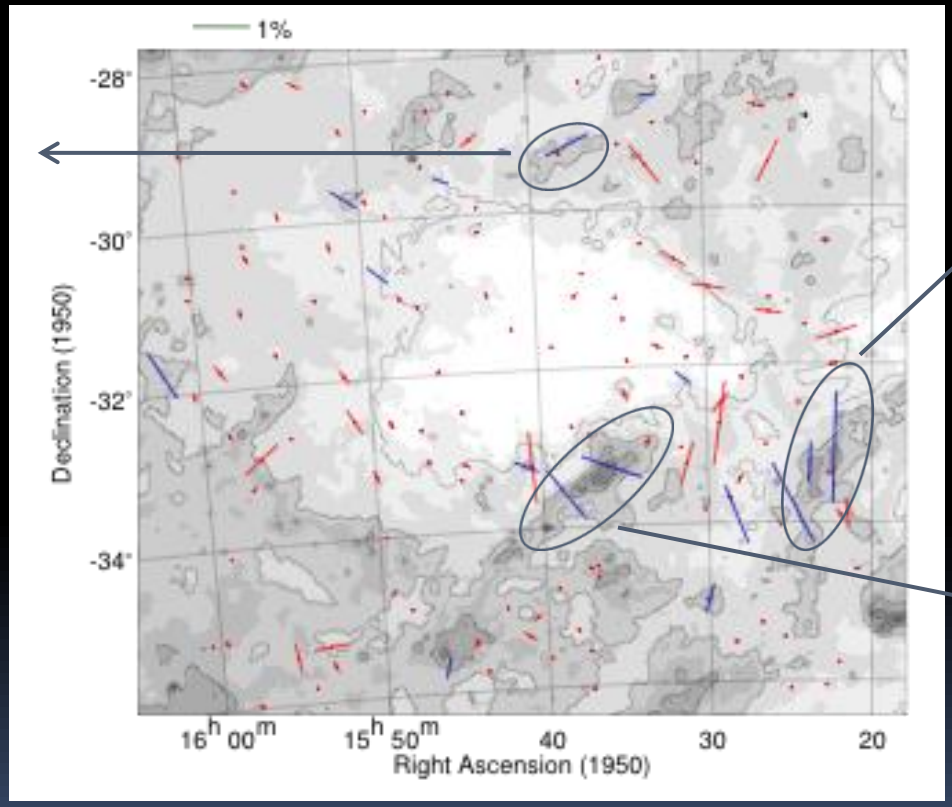
Starlight polarization of molecular clouds

- Limited by A_V. Magnetic field in the diffuse medium.

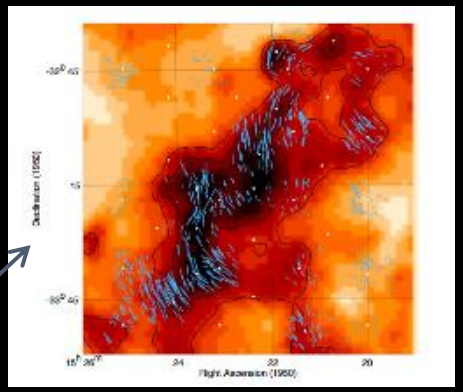


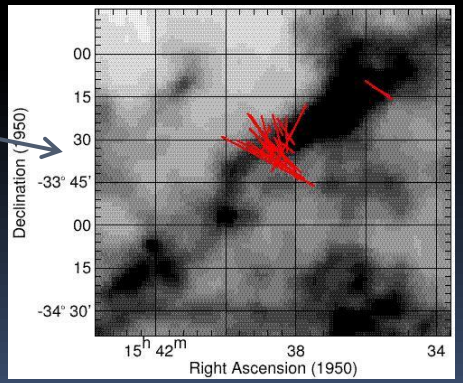


Snake nebula
(Franco et al., in prep)



Starlight polarization in Lupus: Alves et al., 2004 M.Sc. Thesis



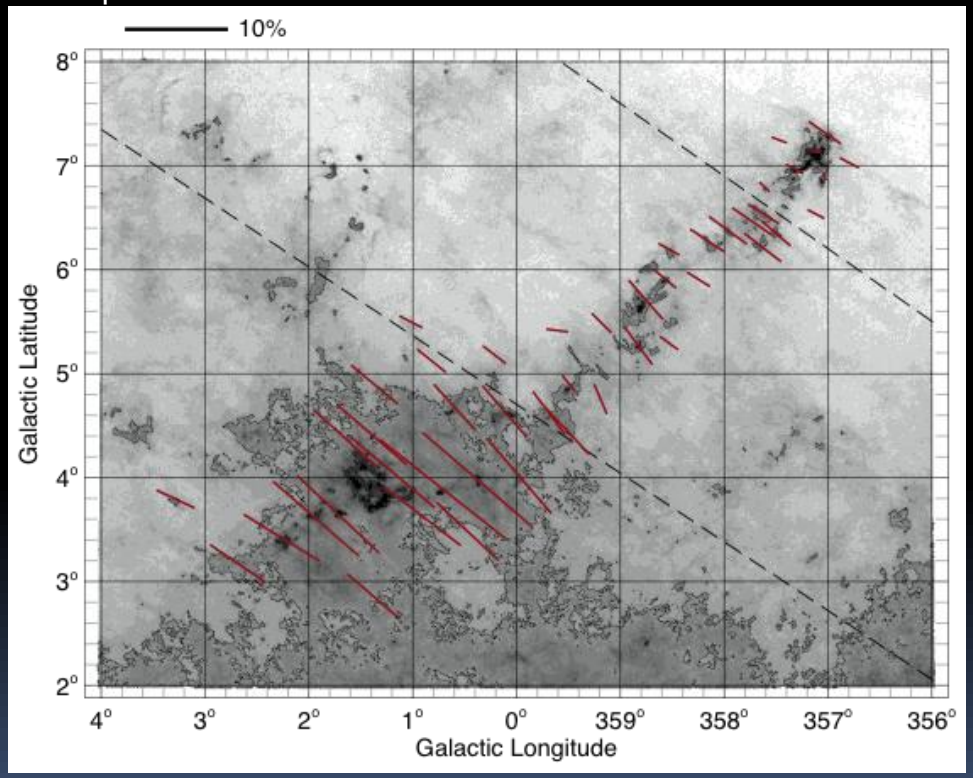


Alves et al., in prep

Starlight polarization of young molecular clouds

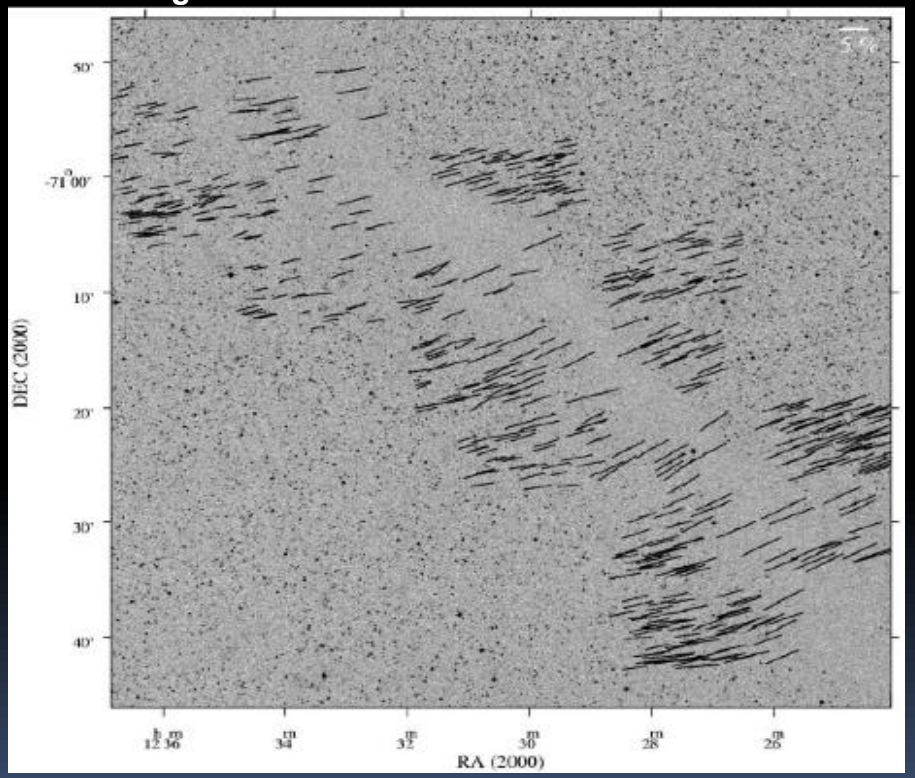
- Magnetically supported clouds at large physical scales: **quiescent** objects

The Pipe nebula



Alves et al. 2007/2008
Franco, Alves & Girart. 2010

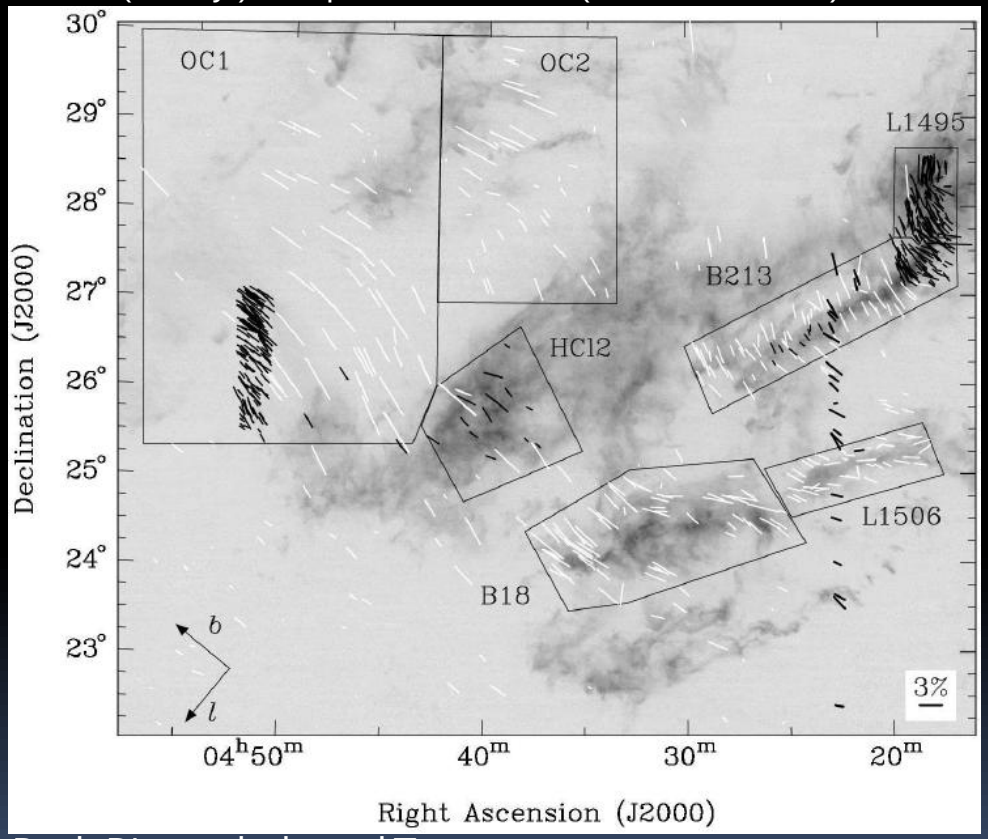
Musca: **Magalhães's talk**



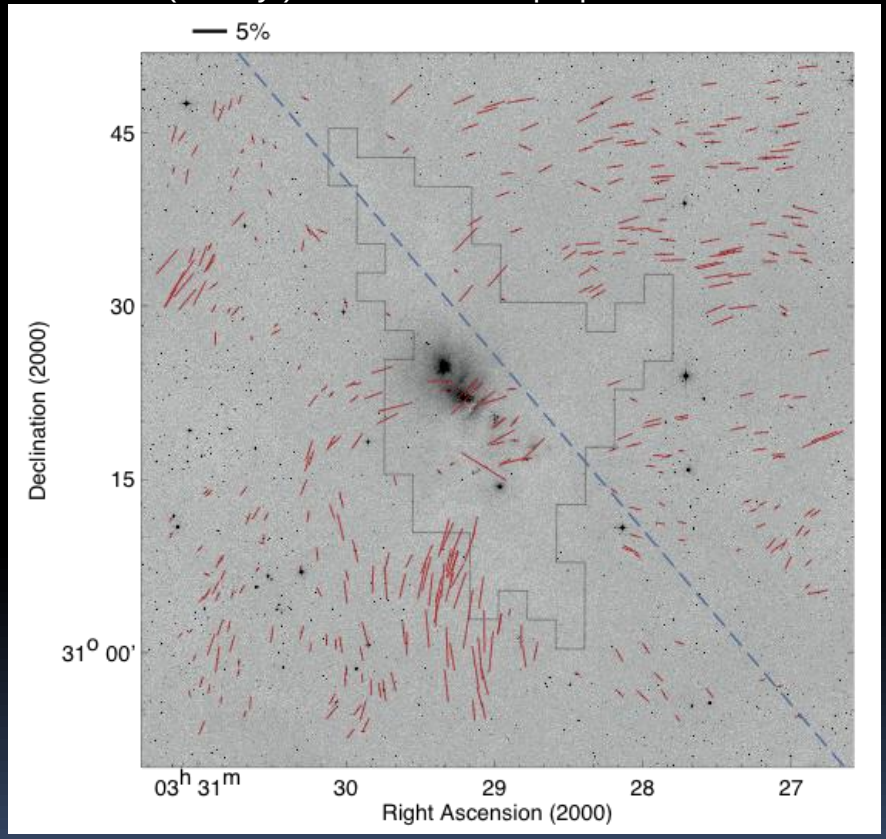
Pereyra & Magalhães, 2004

Starlight polarization of active molecular clouds

Taurus (~ 2 Myr): Chapman et al., 2011 (arXiv: 1108.0410)



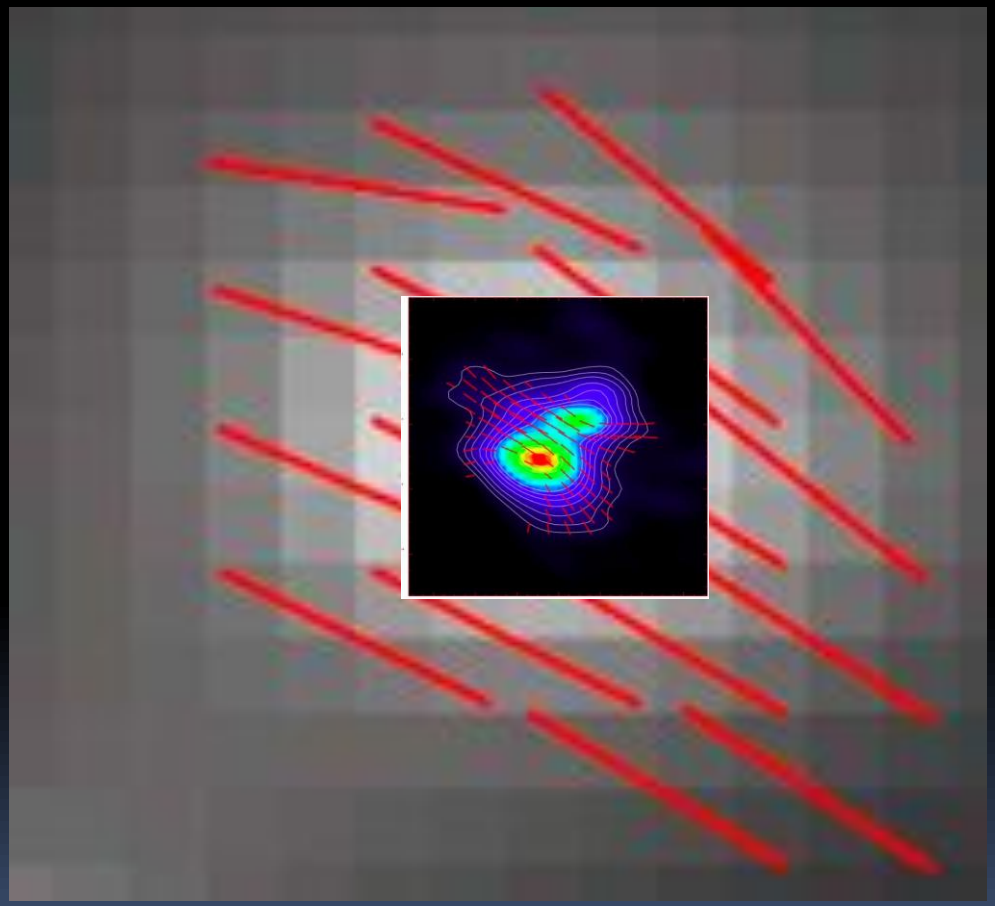
NGC 1333 (~ 1 Myr): Franco et al. in prep.



Both Pipe nebula and Taurus:
p/A_v does not decrease with A_V

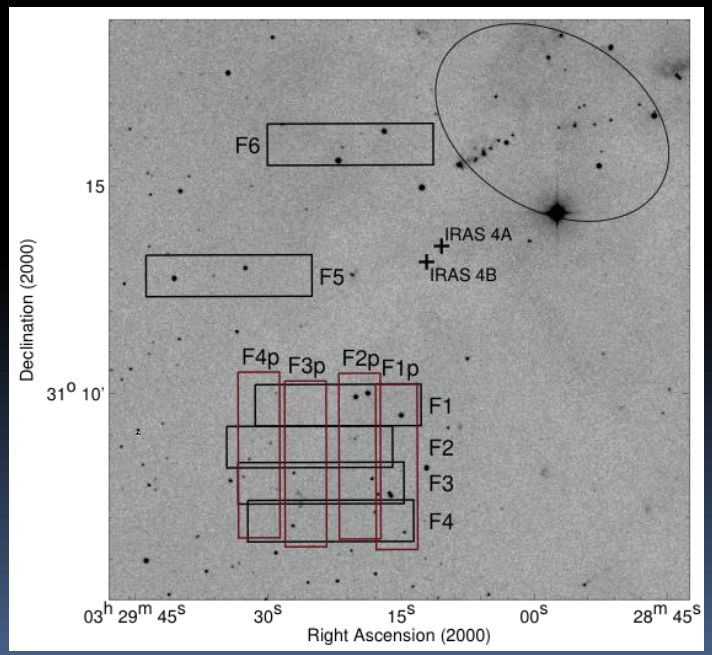
Motivation: the Class 0 protostar NGC 1333 IRAS 4A

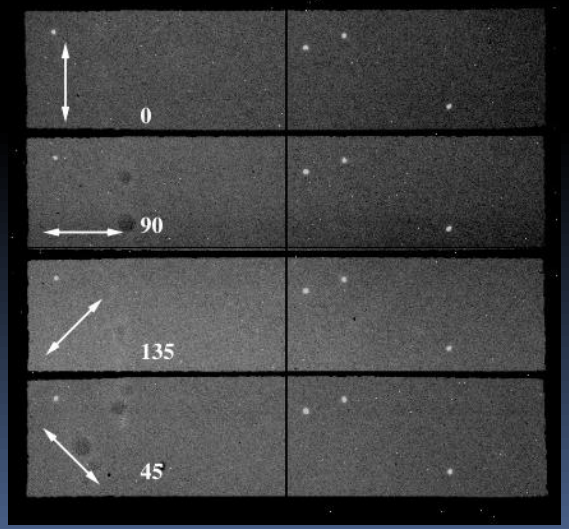
- Goal: compare submm/mm field geometry of IRAS 4A (Girart et al., 1999, 2006; Attard et al., 2009; **Lai's talk**) with ambient cloud field;
- Core in a supercritical state (mass-to-flux ratio > 1), gravitational collapse deforms the core B-field shape: hourglass morphology;
- Study how B-field evolves from molecular clouds (parsec scales) down to circumstellar environments (tens of AU)



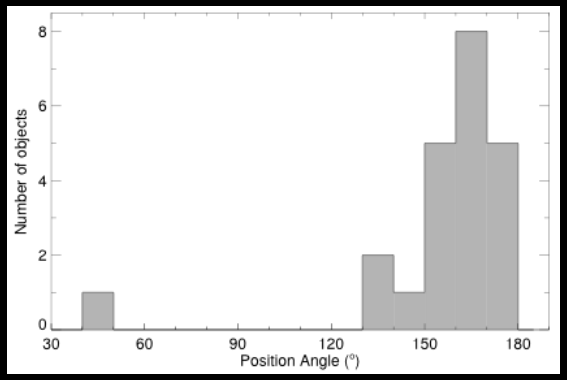
Observations

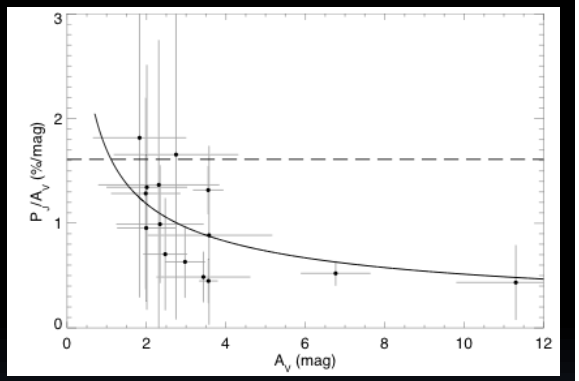
- 4.2 m William Herschel Telescope (ING, La Palma, Spain); observations 2006 and 2007 December
- *J*-band polarimetry using LIRIS;
- Ambient field traced at about 6’ (~ 0.5 pc) from IRAS 4A
- Fields: 4’ x 1’



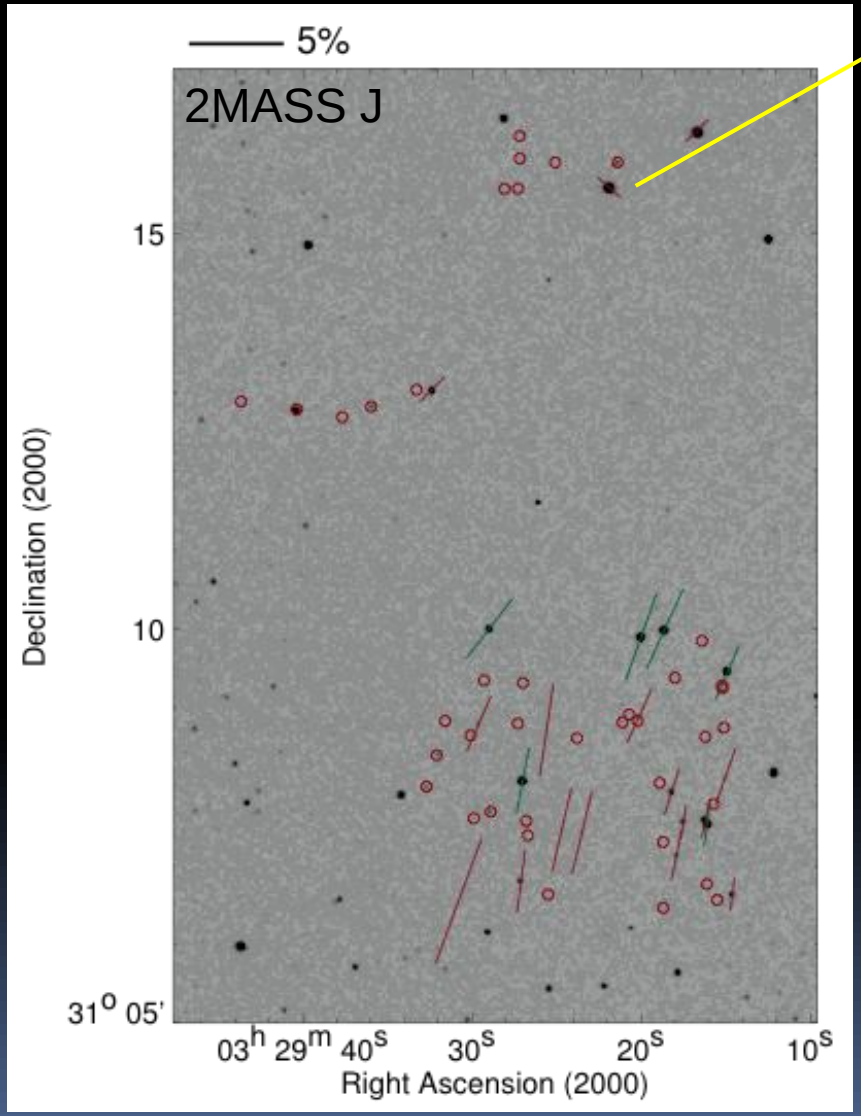


LIRIS near-IR polarimetry





LIRIS probe deeper visual extinctions than 2MASS



Lkhα 271: CTTS

Polarization due internal scattering within optically thin disk.

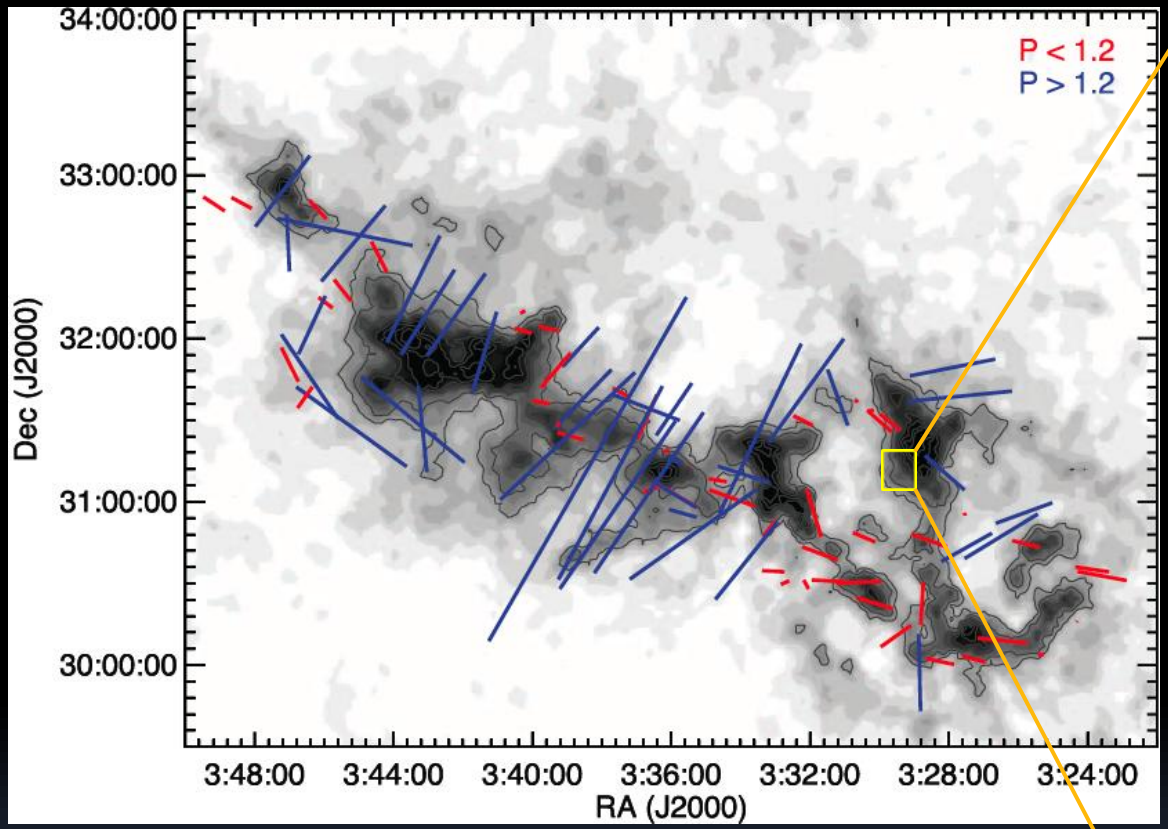
Remaining: interstellar **absorption**

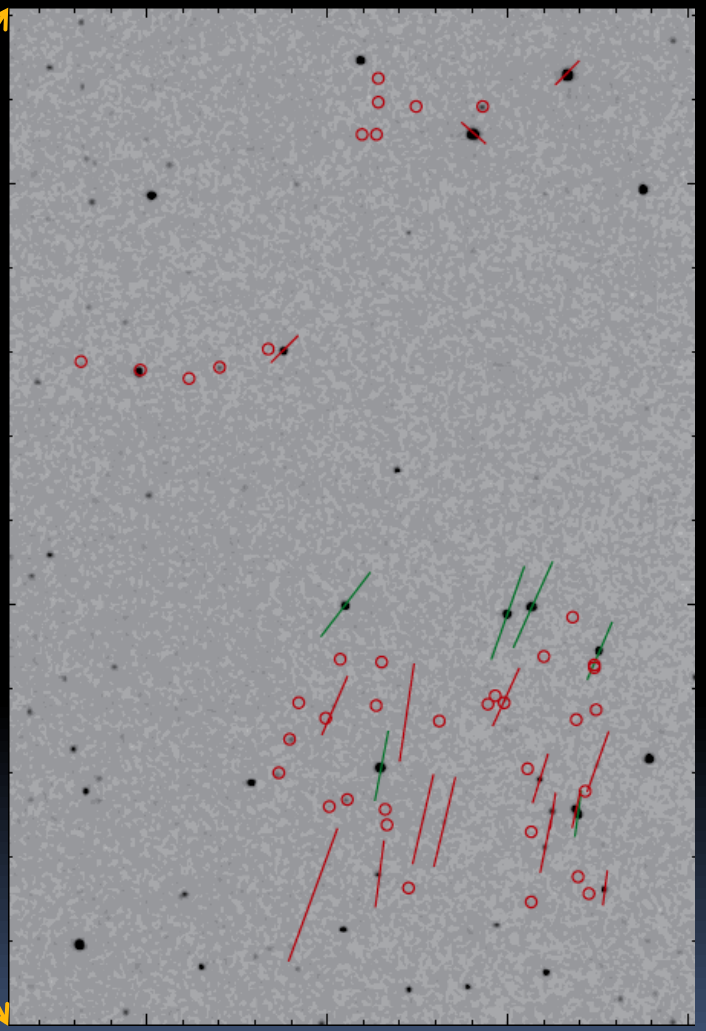
Limit magnitude: J ~18

Mean PA ≅ 160°

Pol: 1.1 % < P < 4.6 %

LIRIS near-IR polarimetry



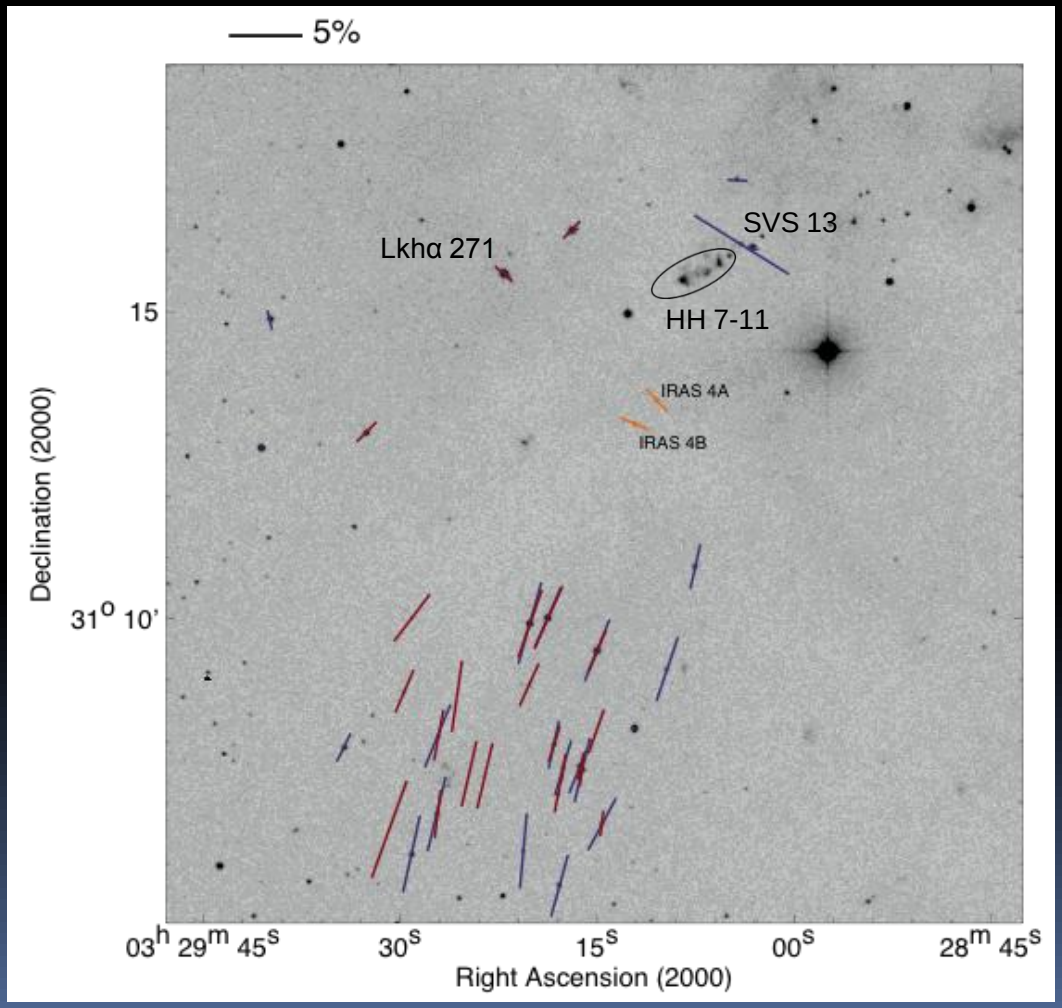


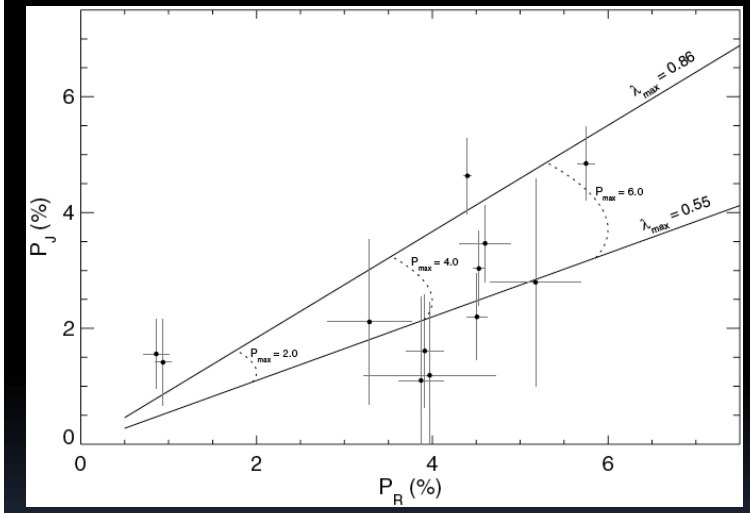
Ridge et al. (2006); Goodman et al. (1990)

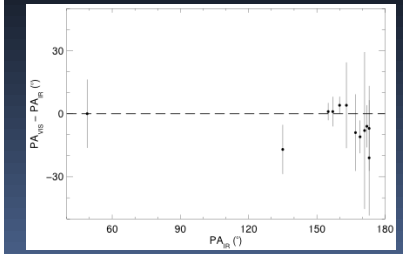
Consistent with $A_v > 0.7$ (Ridge et al, 2006)

Optical polarimetry

Observations: 1.6 m telescope of the Observatório do Pico dos Dias (LNA/MCT – Brazil)

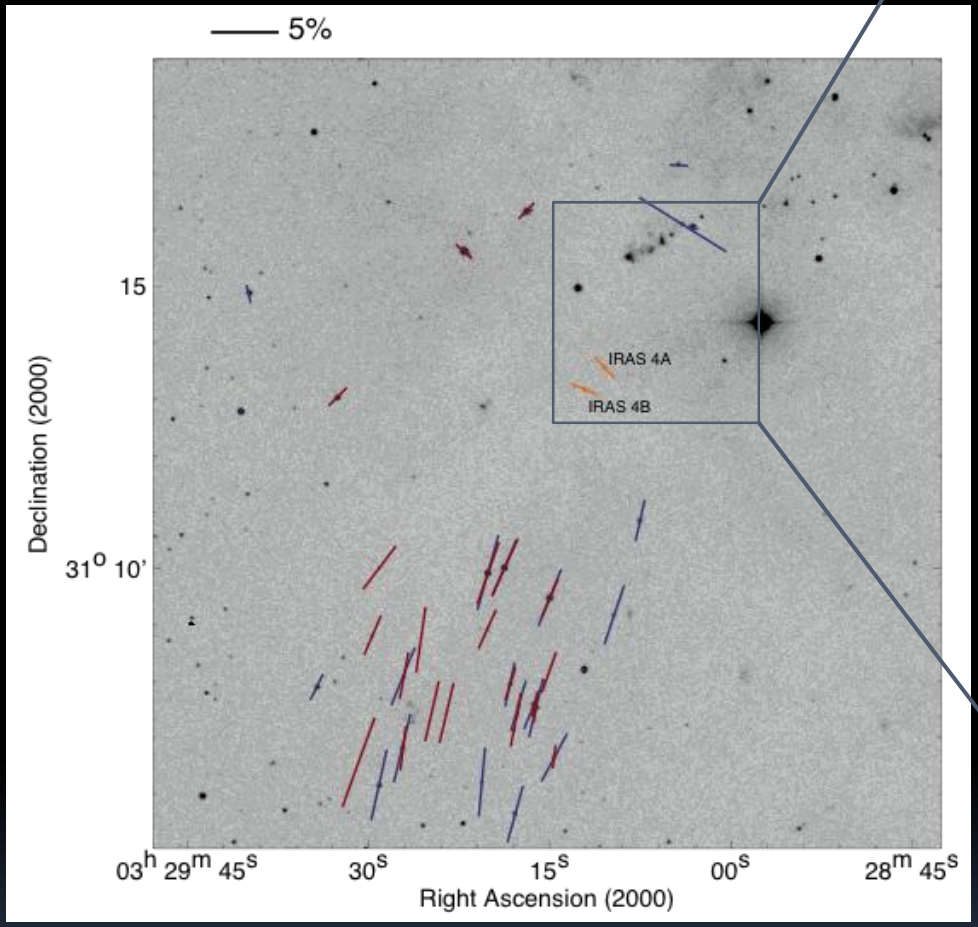


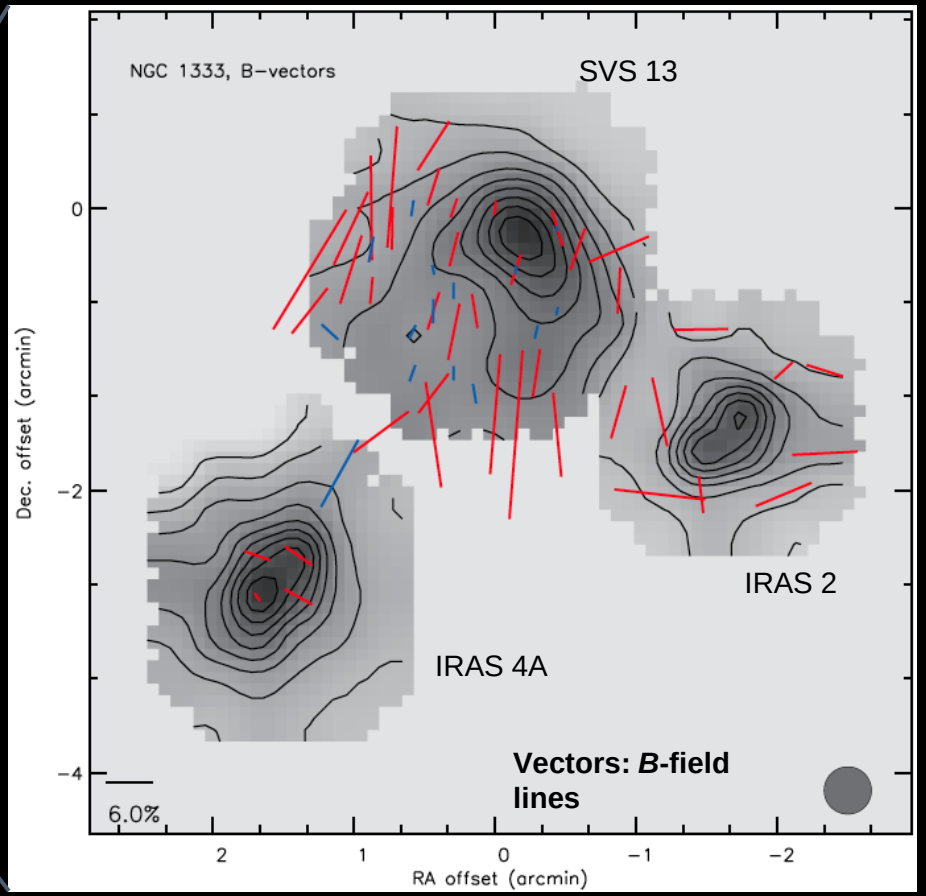




$0.55 < \lambda_{max} < 0.86$ μm

Observations in more bands needed





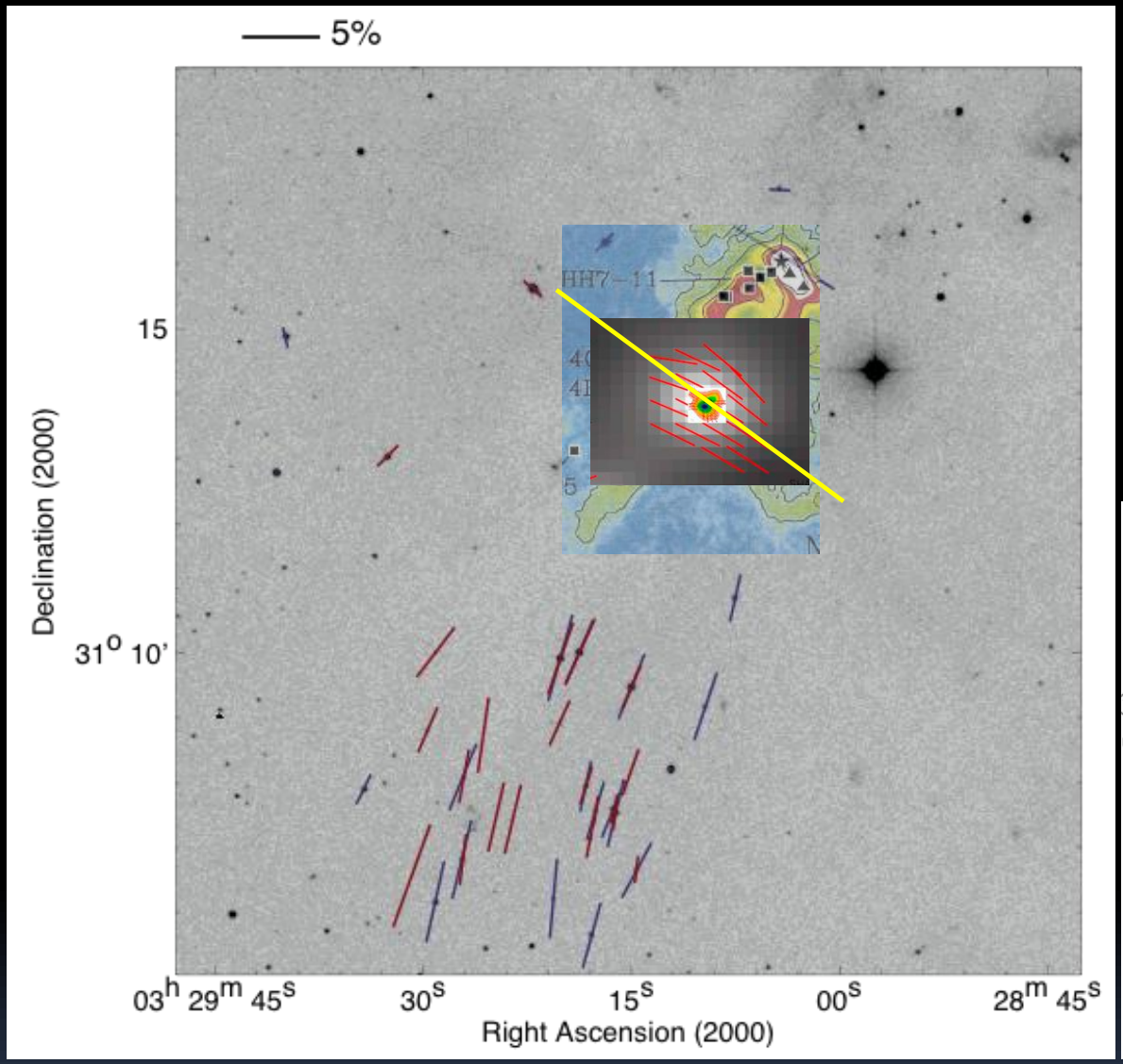
Hertz (CSO) data (350 μm): Dotson et al. (2010)

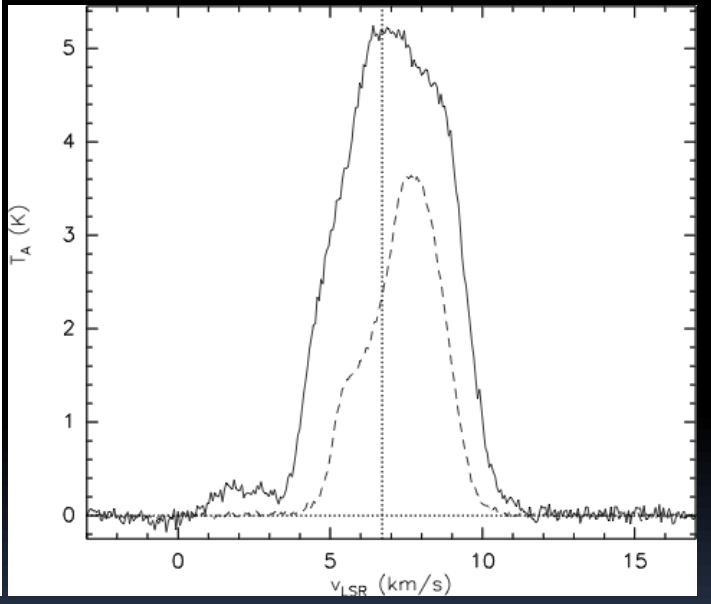
PA_{350} ~ 175° (Stephens et al., 2011)

Consistent with SCUBA (850 μm) data of Matthews et al. (2009), SHARP (350 μm) data of Attard et al. (2009) and SMA (870 μm) data of Girart et al. (2006)

SCUBA dust continuum data from Sandell & Knee (2001): filamentary distribution;

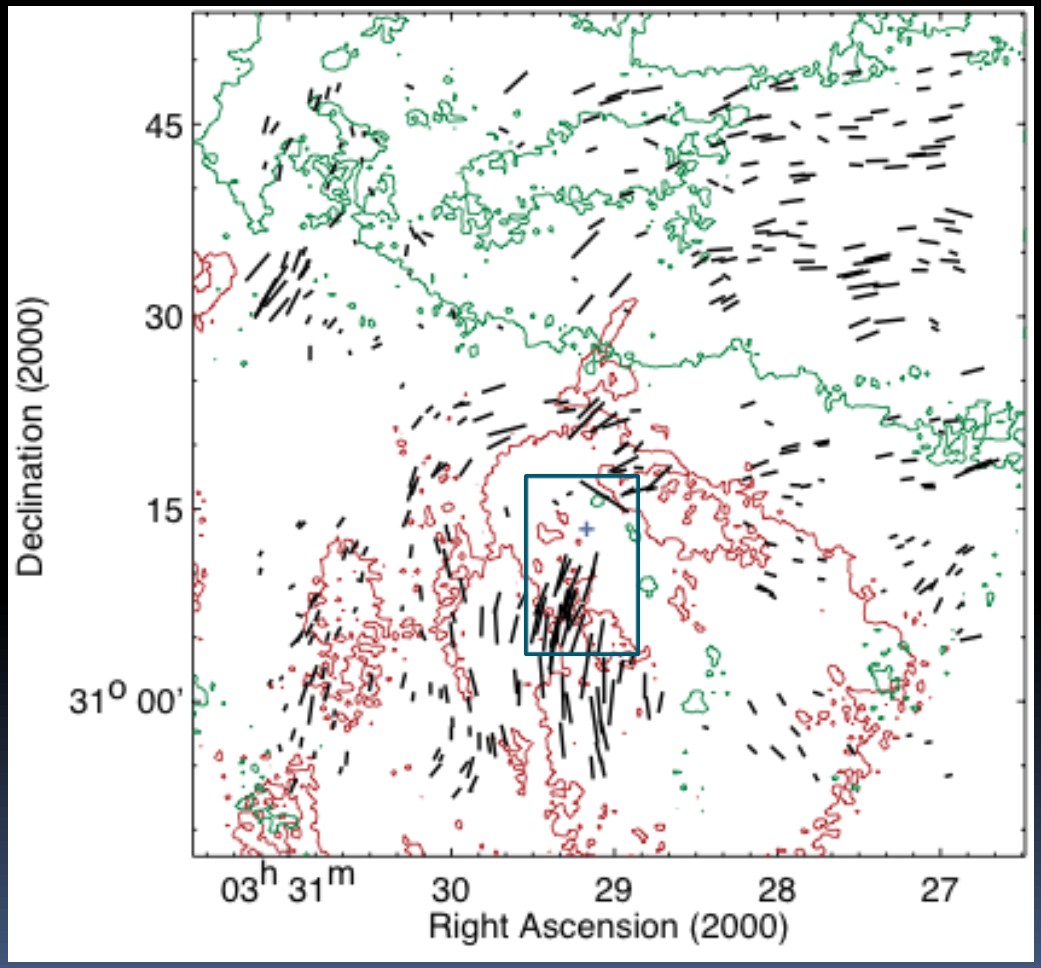
Dense molecular tracers (N_2H^+, HCO^+) also show filaments (Olmi et al., 2005; Walsh et al., 2007).





CO data from COMPLETE survey (Ridge et al., 2006; Pineda et al., 2008)

The ambient magnetic field of NGC 1333



Integrated ^{12}CO maps of COMPLETE
(Ridge et al., 2006)

Red contours: v_{lsr} ~ 3 – 4 km/s

Green contours: v_{lsr} ~ 5 – 9 km/s

Franco, 2011: priv. comm.

Summary

• Near-IR polarimetry highly consistent with optical data: LIRIS scientifically trustful for the astronomical community;

• Polarization map dominated by a well-ordered field component, although contamination by YSO's contributed to increase dispersion in PA;

• B_{cloud} is not aligned with $B_{IRAS\ 4A}$;

• COMPLETE: multi-layered diffuse gas toward the surveyed line-of-sight;

• Observed magnetic field is the average over distinct cloud velocity components.

• More info: **Alves, Acosta-Pulido, Girart, Franco & López, AJ 2011**