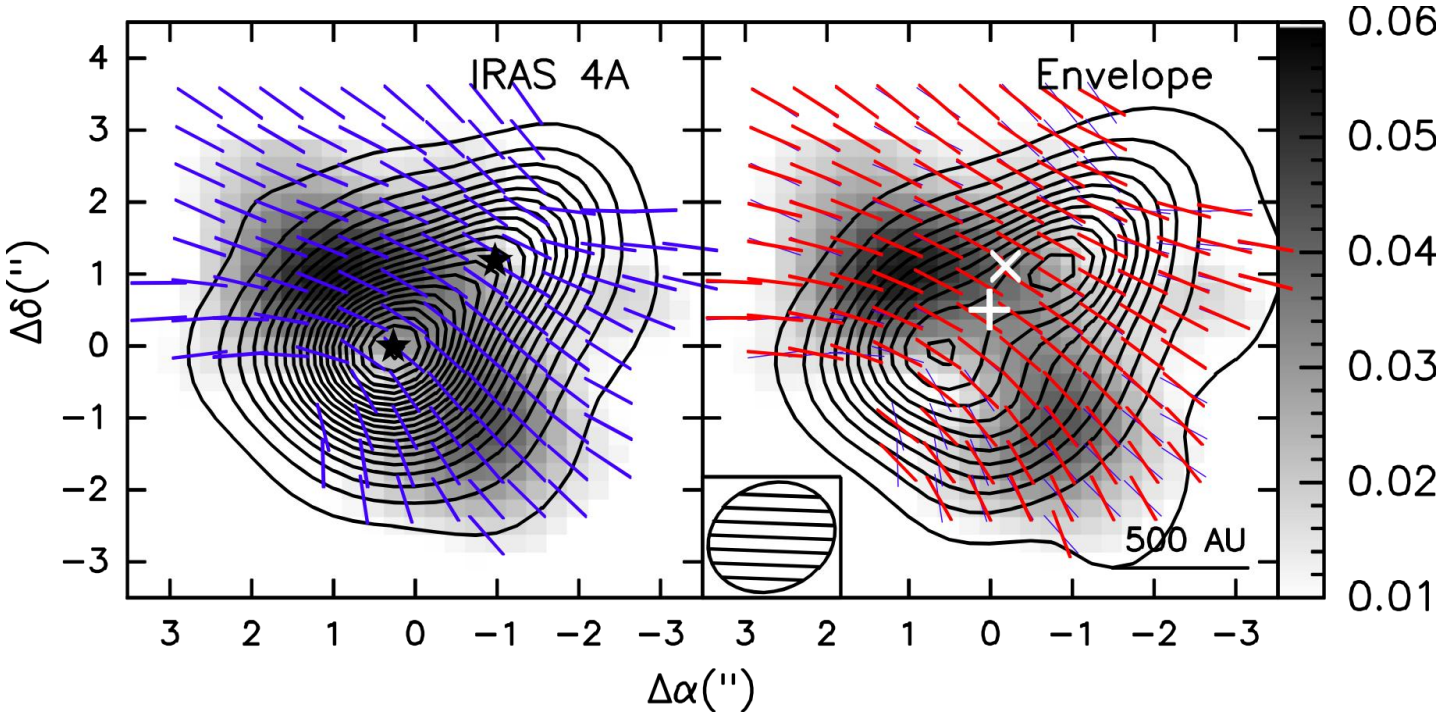
ALMA & polarization

Linear polarization to trace magnetic fields in

- Zeeman effect ……. CN, CCH 3mm (1mm?)
- Dust linear polarization …….. 1.1 – 0.8 mm
- Goldreich-Kylafis pol …… CO, SiO, CS 3mm, 1mm



Molecular line polarization: Theory

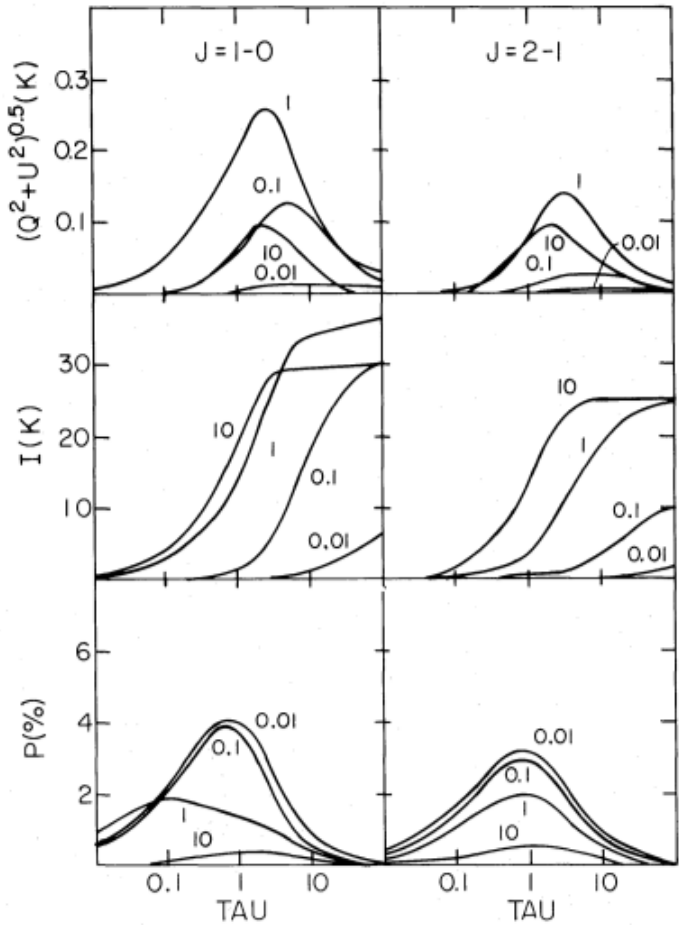


FIG. 3

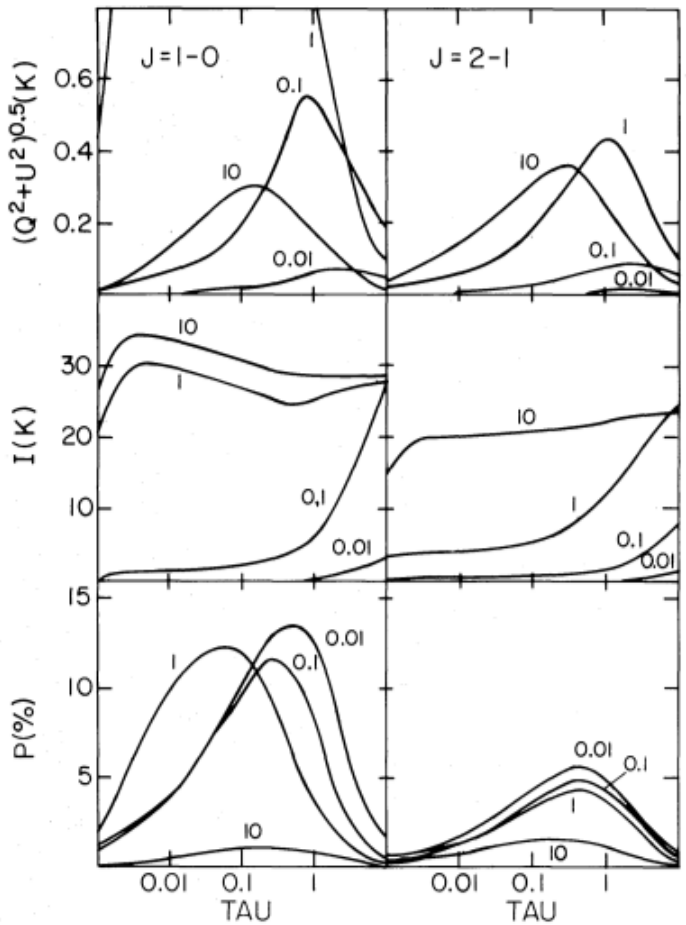


FIG. 4

Highest polarization at τ~1 and n ~n_{crit}

Deguchi & Watson1984

Molecular line polarization: Theory

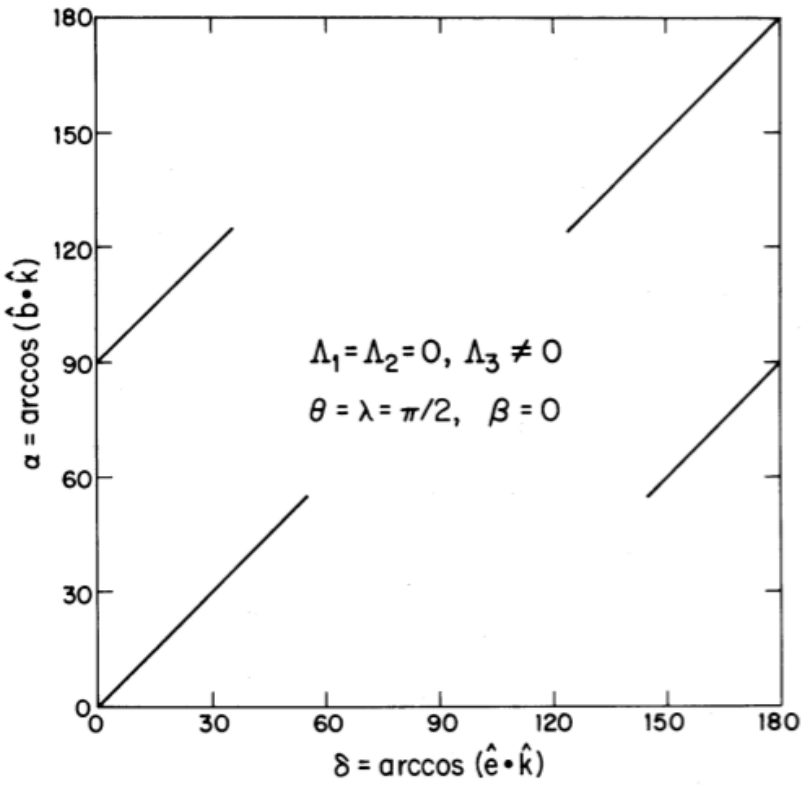


FIG. 5a

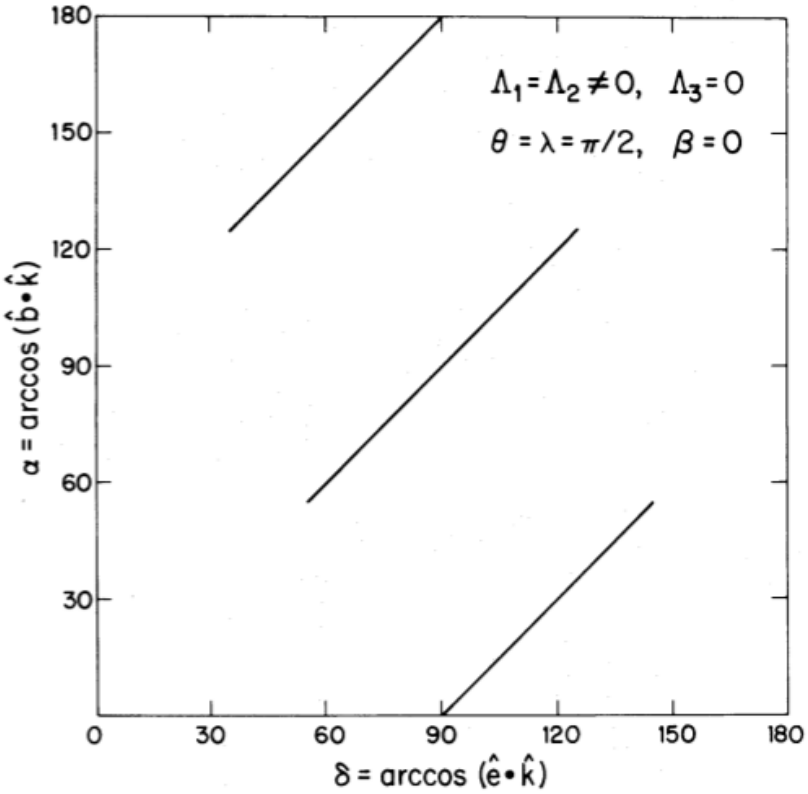


FIG. 5b

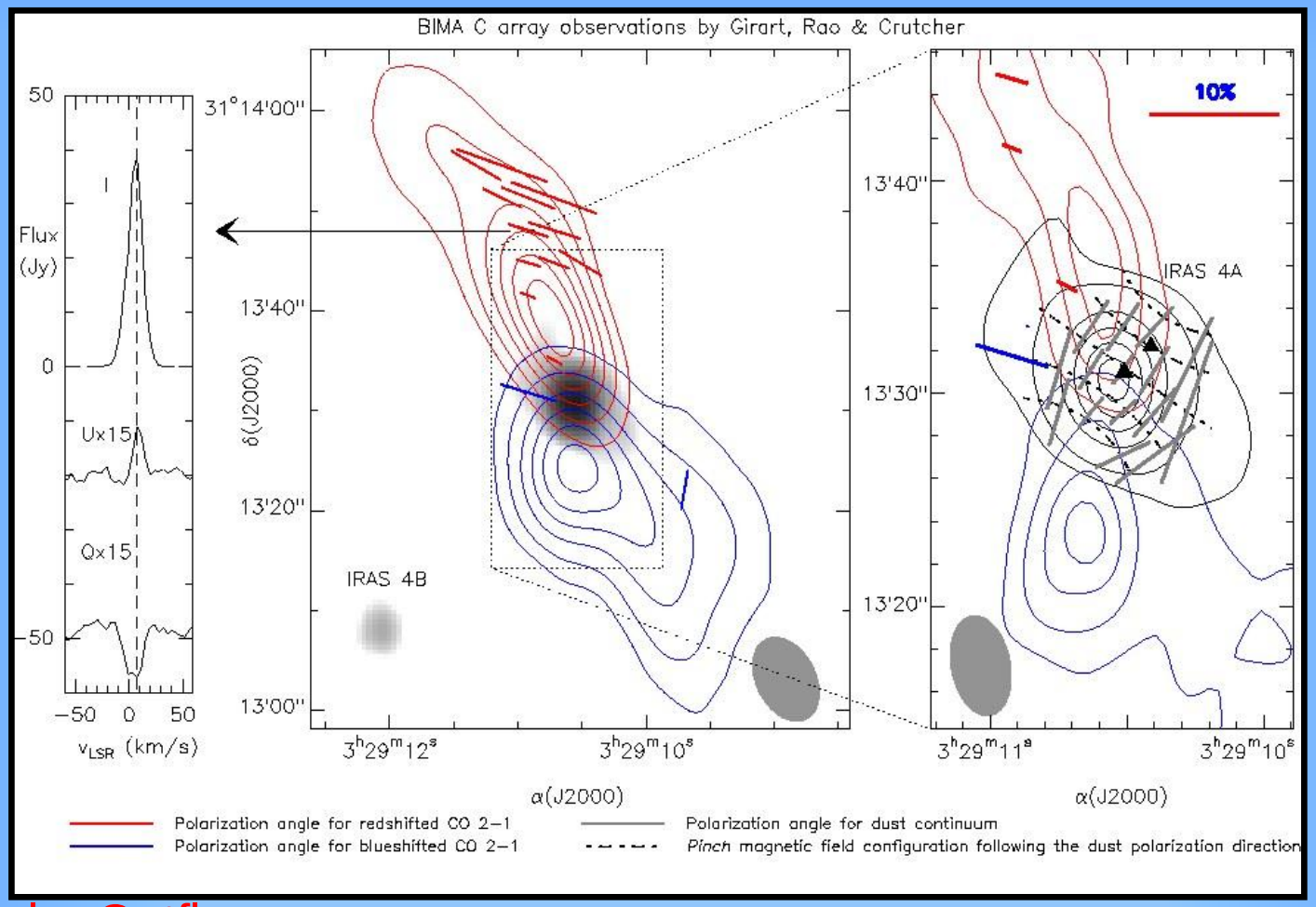
FIG. 5.—(*a*) Relationship between observed polarization vector and magnetic field direction in a one-dimensional velocity field. (*b*) Same as Fig. 5*a* but for a two-dimensional velocity field.

Velocity field is needed to disentangle the ambiguity between PA_B and PA_{pol}

Goldreich & Kylafis 1981, 1982; Kylafis 1983

Molecular line polarization: OBSERVATIONS

NGC 1333 IRS 4A



Girart, Crutcher & Rao 1999, ApJ, 525, L109

Molecular Outflow:

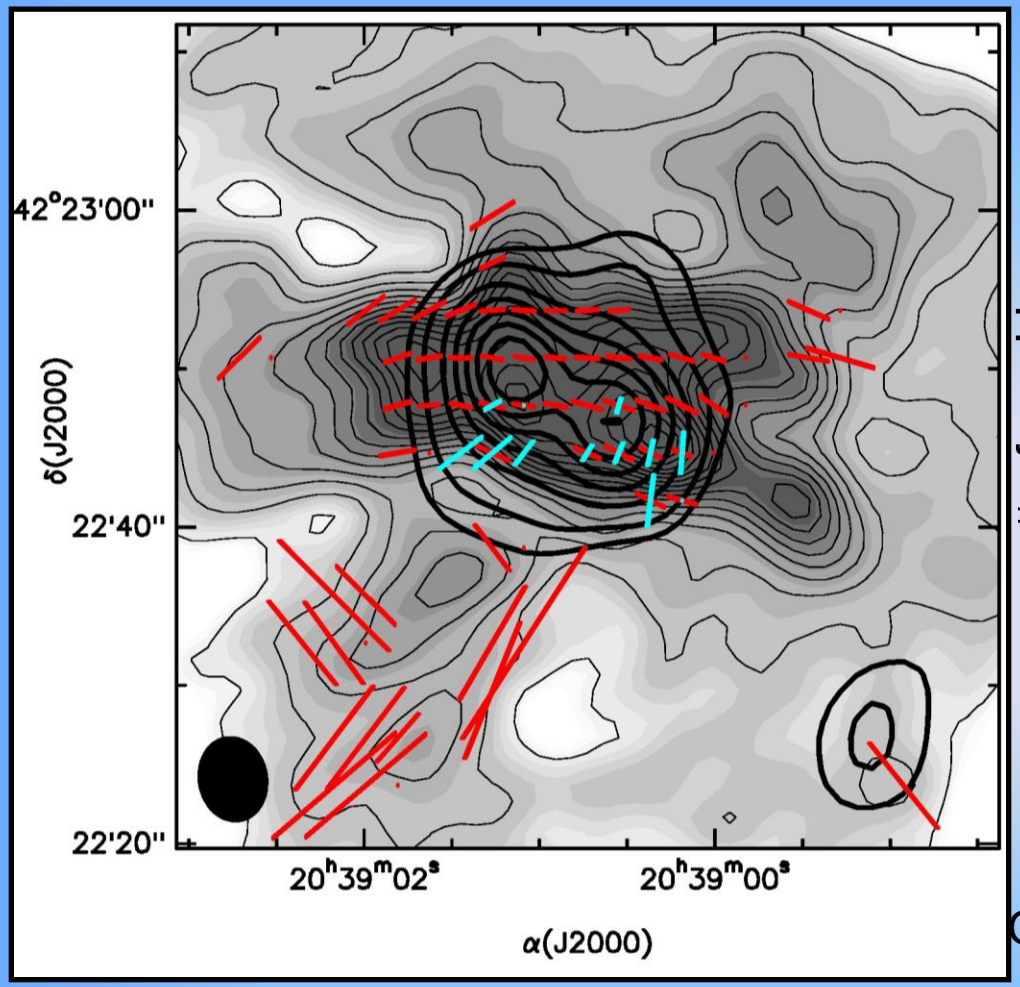
First mapping of the Goldreich-Kylafis pol. (CO 2-1). Pol. vectors || **B**

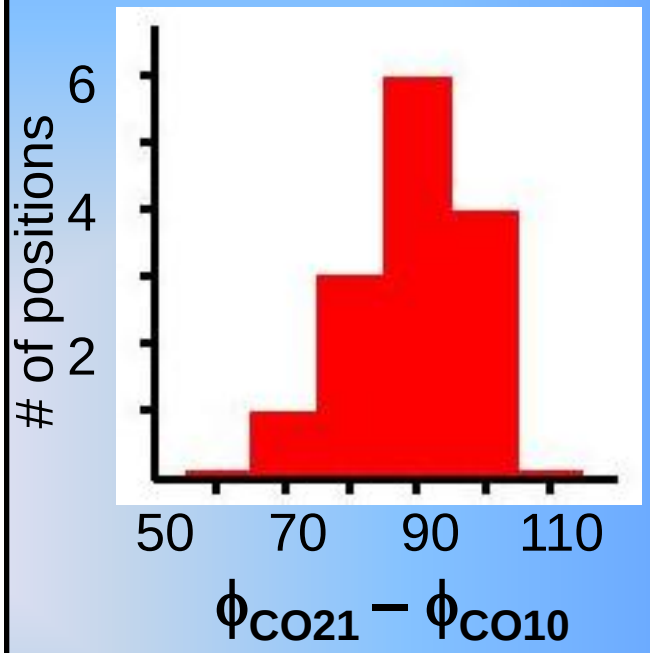
Dusty Core:

Pol. distribution: an hour-glass shape magnetic field as predicted by theory

Molecular line polarization: OBSERVATIONS

DR 21 OH





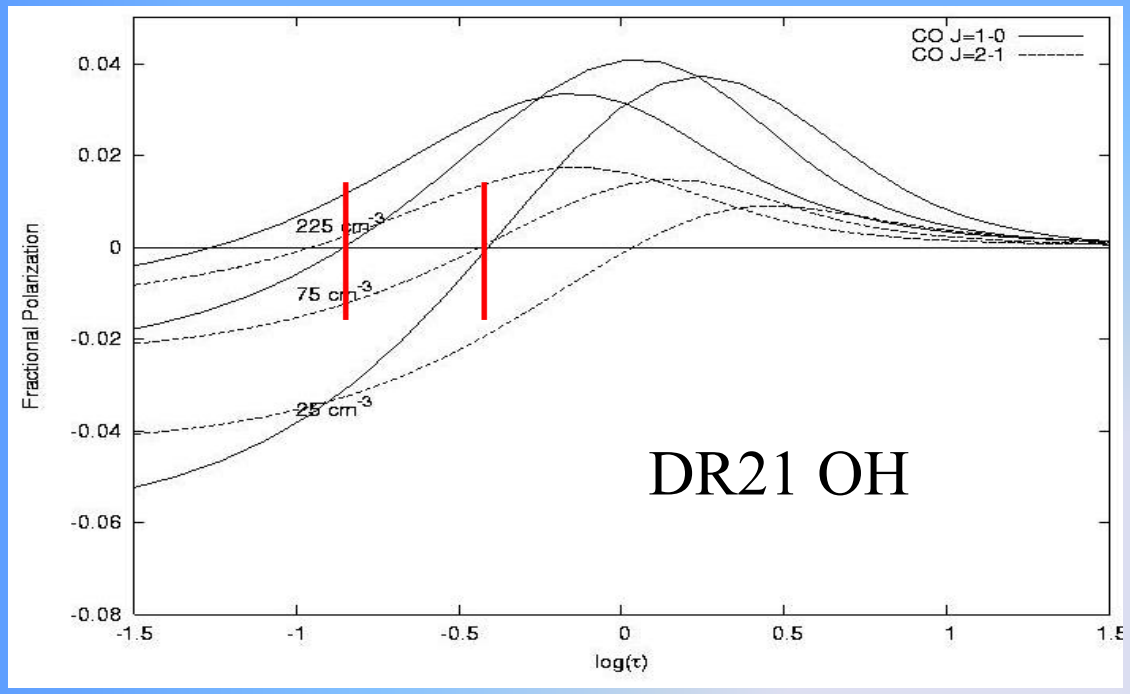
Lai, Girart, Crutcher 2001

Cortes, Crutcher, & Watson 2005

Detected both the dust and CO 2-1 polarization.

- Dust polarization detected in only several scattered positions
- PA(CO) ⊥ PA(dust) (although the dispersion is large)

Molecular line polarization: Theory



- $n(H_2) \sim 10^2$: Strongly magnetized, subritical, cloud
- $n(H_2) \sim 10^6$: supercritical region, turbulence provides main support to gravity

1. CO polarization:
   $n(H_2) \sim 10^2$, $B_{pos} \approx 0.01$ mG
2. Dust polarization & CN Zeeman:
   $n(H_2) \sim 10^6$, $N(H_2) \approx 3 \times 10^{23}$
   $B_{pos} \approx B_{los} \approx 0.7$ mG, $\lambda_c \approx 1.1$

Cortes, Crutcher, & Watson 2005

Combining 1 and 2:
$B \propto \rho^{0.45}$

ALMA & linear polarization

Linear polarization to trace magnetic fields in

- YSO outflows ……CO & SiO
- CSE and pre-PN (outflows? ……. CO, SiS, CS, SiO
- YSO disks …… dust

Issues:

- CO emission can be very extended (wrt ALMA field of view)
- ALMA off-axis instrumental pol response
- DON'T create pol maps without checking Q & U maps