Reconstructing the Full 3D Morphology of Magnetic Fields Associated with Filamentary Molecular Clouds

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3D magnetic fields (B) in Filamentary Molecular Clouds

- Line-of-sight B field using Faraday rotation
- Combination of line-of-sight and plane-of-sky B fields
- Combination of Galactic B and velocity information
Line-of-Sight Magnetic Observations

\[ \Delta \Psi \ (\text{rad}) = \lambda^2 \left( 0.812 \int n_e B \cdot dl \right) = \lambda^2 \text{RM} \]

Tahani et al. 2018:

- Decoupling the contribution from the cloud contribution:
  - Using an On-Off approach

- Finding electron density and dl:
  - Extinction maps
  - Chemical evolution code
Line-of-Sight Magnetic Observations

Magnetic Field Measure in California

Magnetic Field Measure in Orion A

Magnetic Field Measure in Perseus

3D Magnetic Morphology in Orion A

Possible scenarios: Toroidal, Helical, Bow-shaped

- Line-of-sight magnetic field & Planck plane-of-sky magnetic field results
- Constructed models representing the morphologies (helical, toroidal, bow-shaped)

Credit: Saxton, Dame, Hartmann, Thaddeus; NRAO/AUI/NSF - Tim Robishaw
3D Magnetic Morphology in Orion A

Monte-Carlo Analysis

Investigating a range of systematic biases

$X^2$ probability values

Tahani et al. 2019, A&A 632, A68

LIC performed by Kate Pattle
Bow-shaped Magnetic Field Morphology

Inoue et al. 2018
Bow-shaped Magnetic Field Morphology

Dense clouds
Dense HI shell

Inutsuka et al. 2015

cloud
Shock front
before interaction

filament
after interaction

Bow-shaped Magnetic Field Morphology

Dense clouds
Dense HI shell

Inutsuka et al. 2015

cloud
Shock front
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filament
after interaction
Bow-shaped Magnetic Field Morphology
Perseus 3D Magnetic Field Morphology

Tahani et al. Submitted
Orion A 3D Magnetic Field Morphology

Tahani et al. Submitted
Summary

• Developed a method based on Faraday rotation to detect the line-of-sight component of magnetic field associated with molecular clouds.
  – Found that this component reverses from one side of the clouds to the other.
• Using our line-of-sight and Planck’s plane-of-sky magnetic field observations we concluded that the bow-shaped morphology is more probable in Orion A.
• Using Galactic magnetic field models we constructed the 3D morphology of the magnetic fields in the Orion A and Perseus clouds.
Future Directions

• High source density, low uncertainty RM catalogs by SKA, ASKAP (POSSUM), VLASS will facilitate mapping Blos in many more MCs.

• Combining these with the plane-of-sky magnetic fields, using new and improved observations will enable us to study the 3D magnetic fields.

• Velocity observations will further enable us to reconstruct the 3D magnetic field morphologies.

• Zeeman observations will improve these maps.