

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

Mehrnoosh Tahani

Covington Fellow – Dominion Radio Astrophysical Observatory
National Research Council Canada
email: Mehrnoosh.Tahani@nrc.ca

Collaborators [alphabetical order]:

Jo-Anne Brown, Yasuo Doi, Isabelle Grenier, Jennifer Glover*,
Marijke Haverkorn, Shu-ichiro Inutsuka, Jouni Kainulainen, Lewis
Knee, Roland Kothes, Min-Young Lee, Wednesday Lupypciw*,
René Plume, Tim Robishaw, Juan Soler, Jennifer West

*: Co-op undergraduate student

3D magnetic fields (B) in Filamentary Molecular Clouds

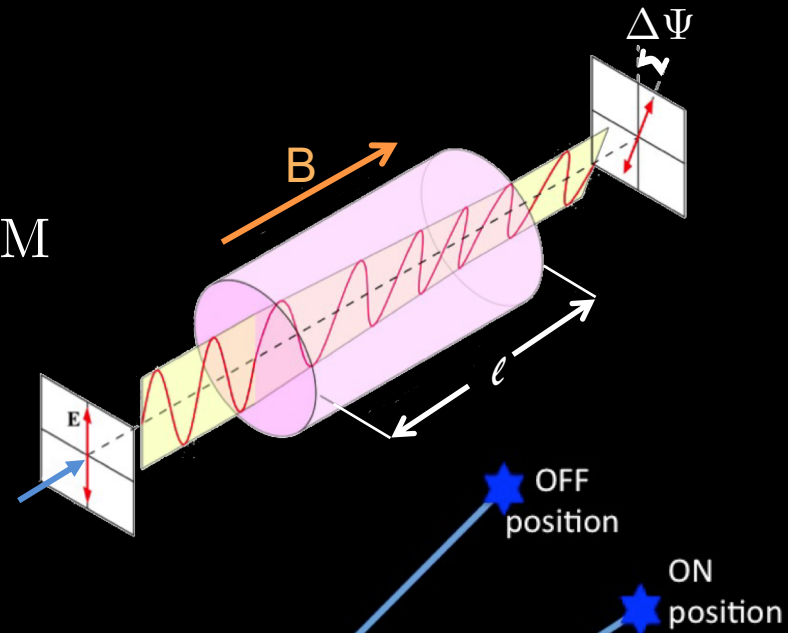
Line-of-sight B field
using Faraday rotation

Combination of line-of-
sight and plane-of-sky B
fields

Combination of Galactic
B and velocity
information

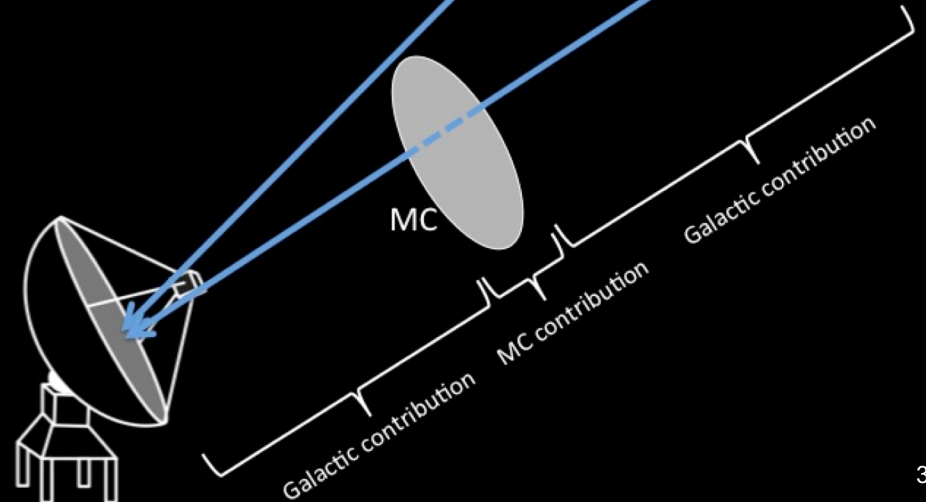
Line-of-Sight Magnetic Observations

$$\Delta\Psi \text{ (rad)} = \lambda^2 \left(0.812 \int n_e \mathbf{B} \cdot d\mathbf{l} \right) = \lambda^2 \text{RM}$$



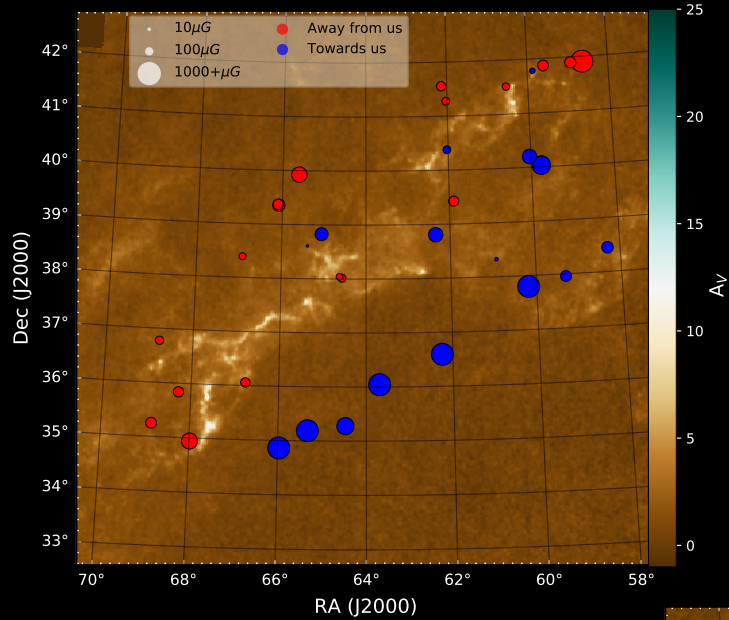
Tahani et al. 2018:

- Decoupling the contribution from the cloud contribution:
 - Using an On-Off approach
- Finding electron density and dl:
 - Extinction maps
 - Chemical evolution code

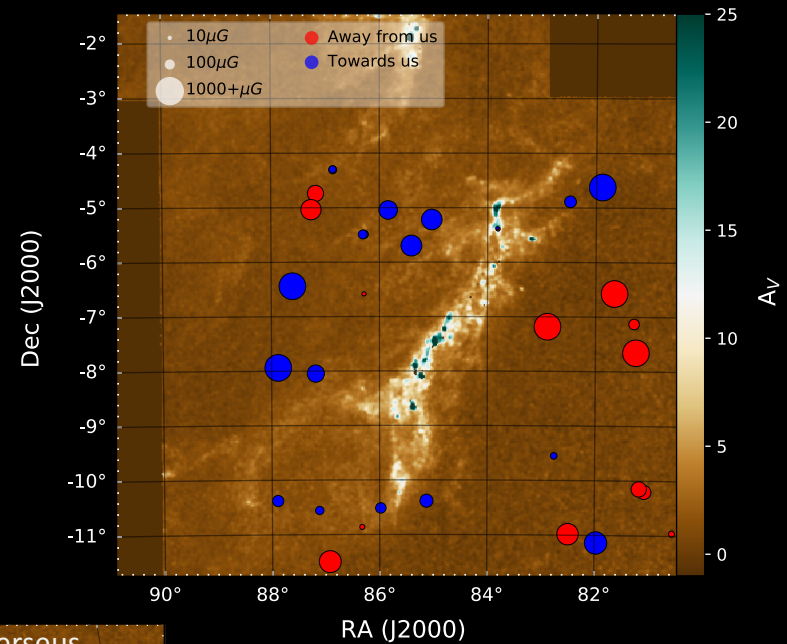


Line-of-Sight Magnetic Observations

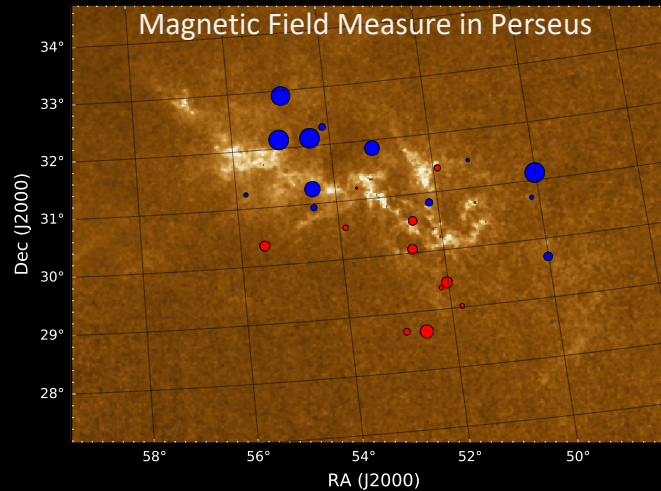
Magnetic Field Measure in California



Magnetic Field Measure in Orion A



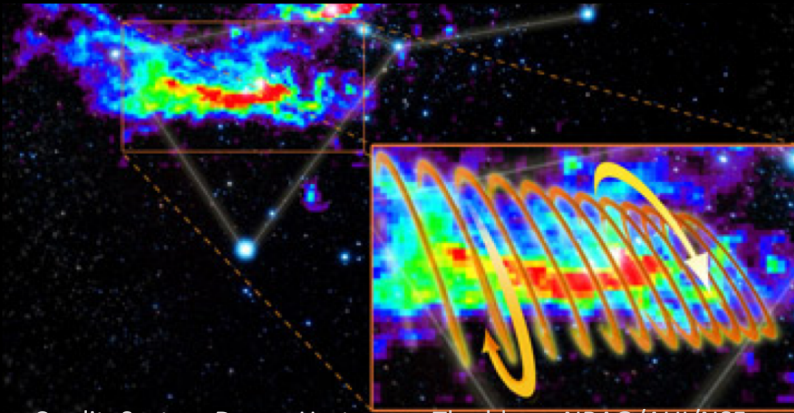
Magnetic Field Measure in Perseus



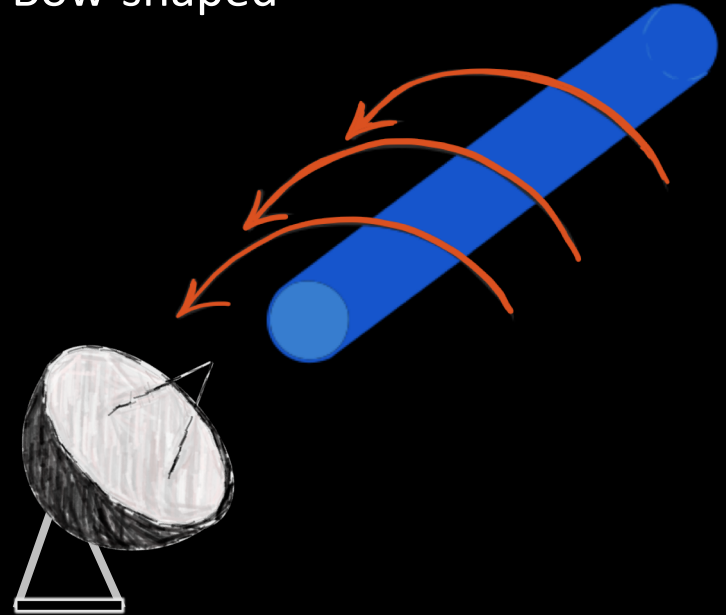
Tahani et al. 2018, A&A, 614, A100

3D Magnetic Morphology in Orion A

Possible scenarios: Toroidal, Helical, Bow-shaped



Credit: Saxton, Dame, Hartmann, Thaddeus; NRAO/AUI/NSF
- Tim Robishaw



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

3D Magnetic Morphology in Orion A

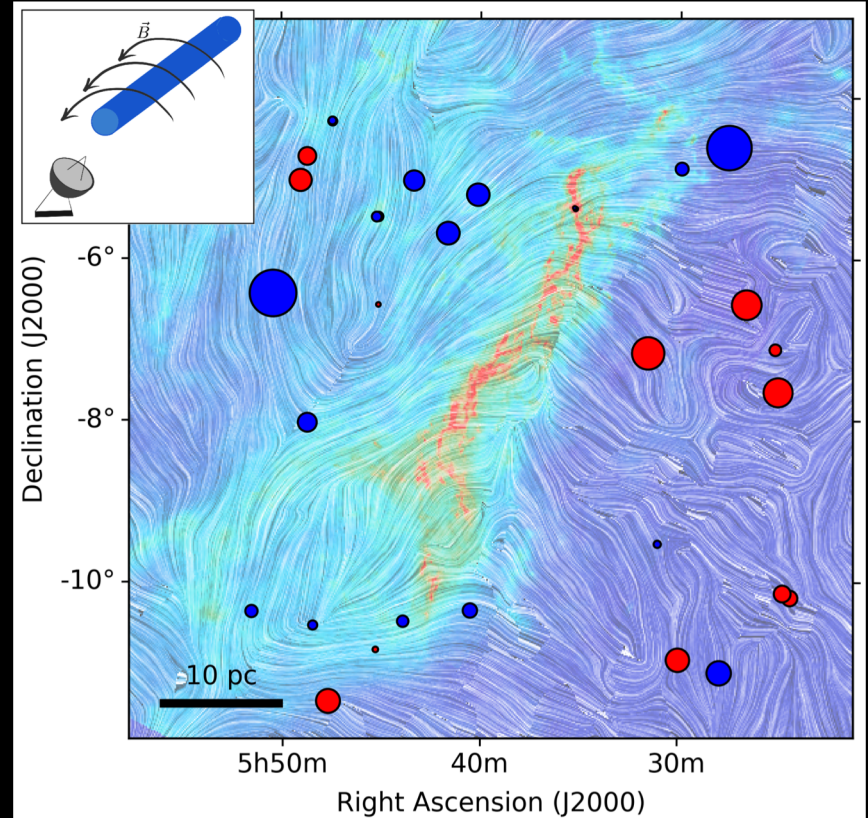
Monte-Carlo Analysis

+

Investigating a range
of systematic biases

+

χ^2 probability values

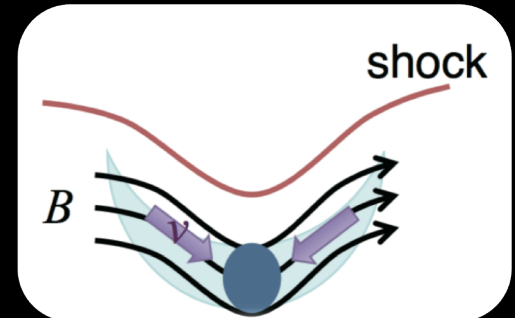
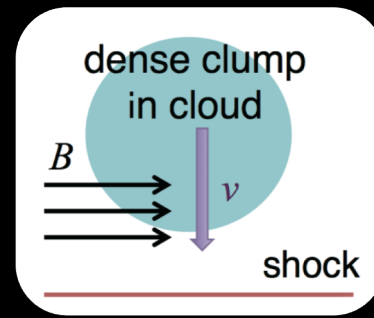
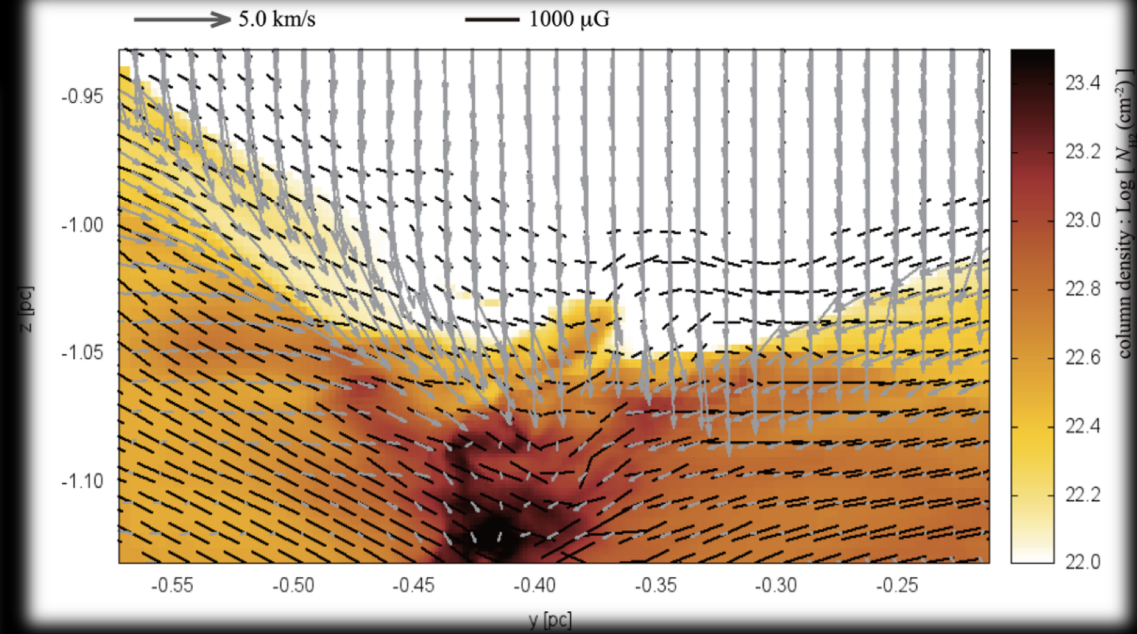
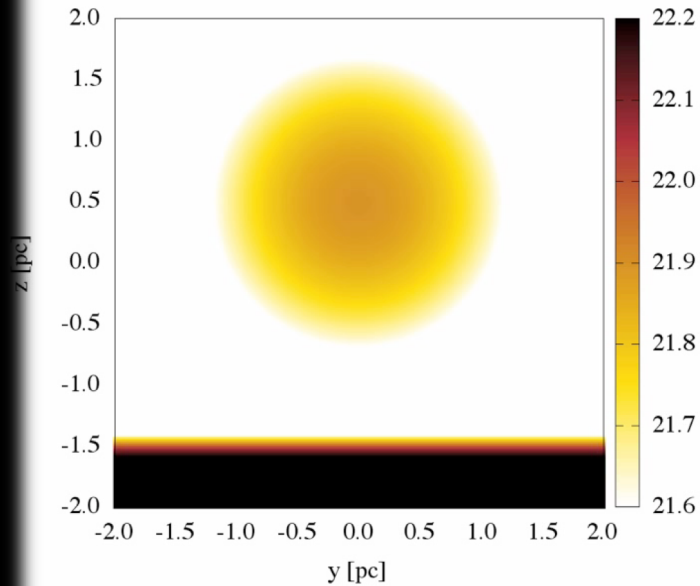


LIC performed by Kate Pattle

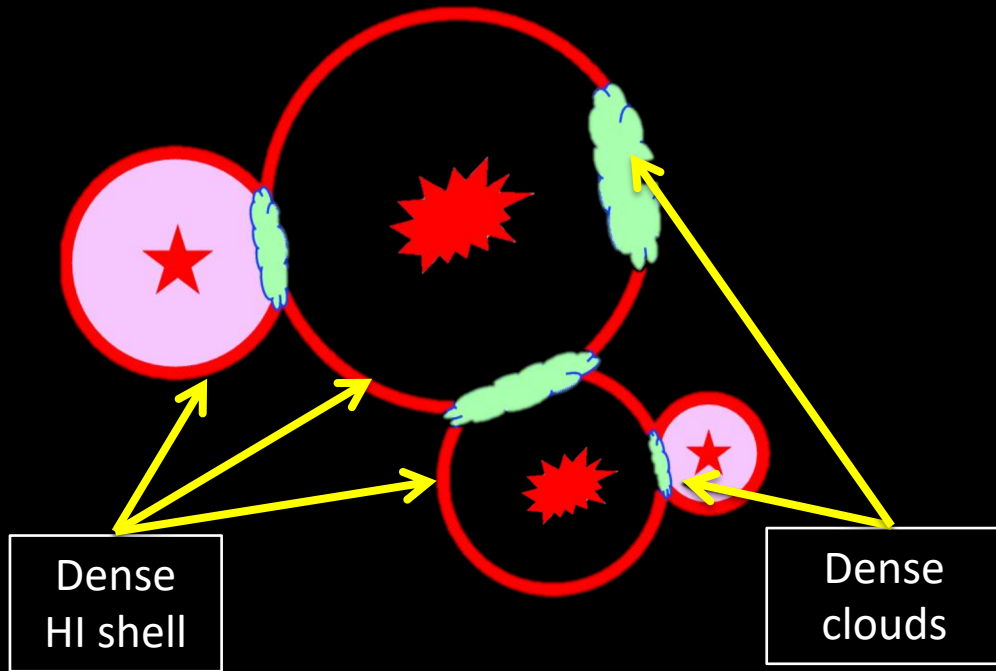
Tahani et al. 2019, A&A 632, A68

Bow-shaped Magnetic Field Morphology

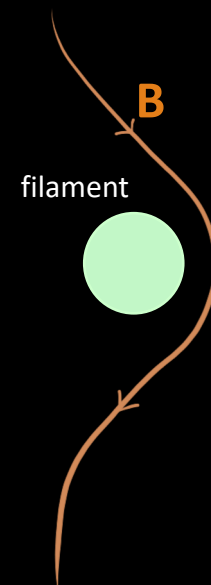
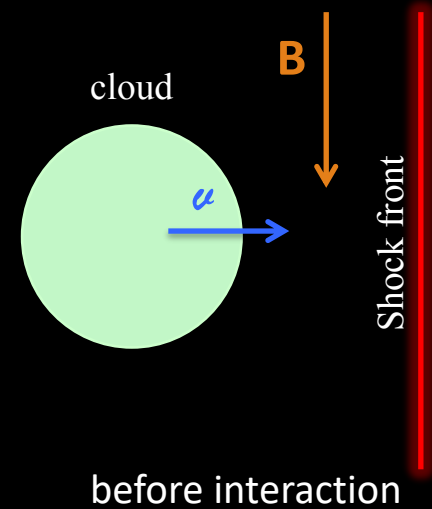
Inoue et al. 2018



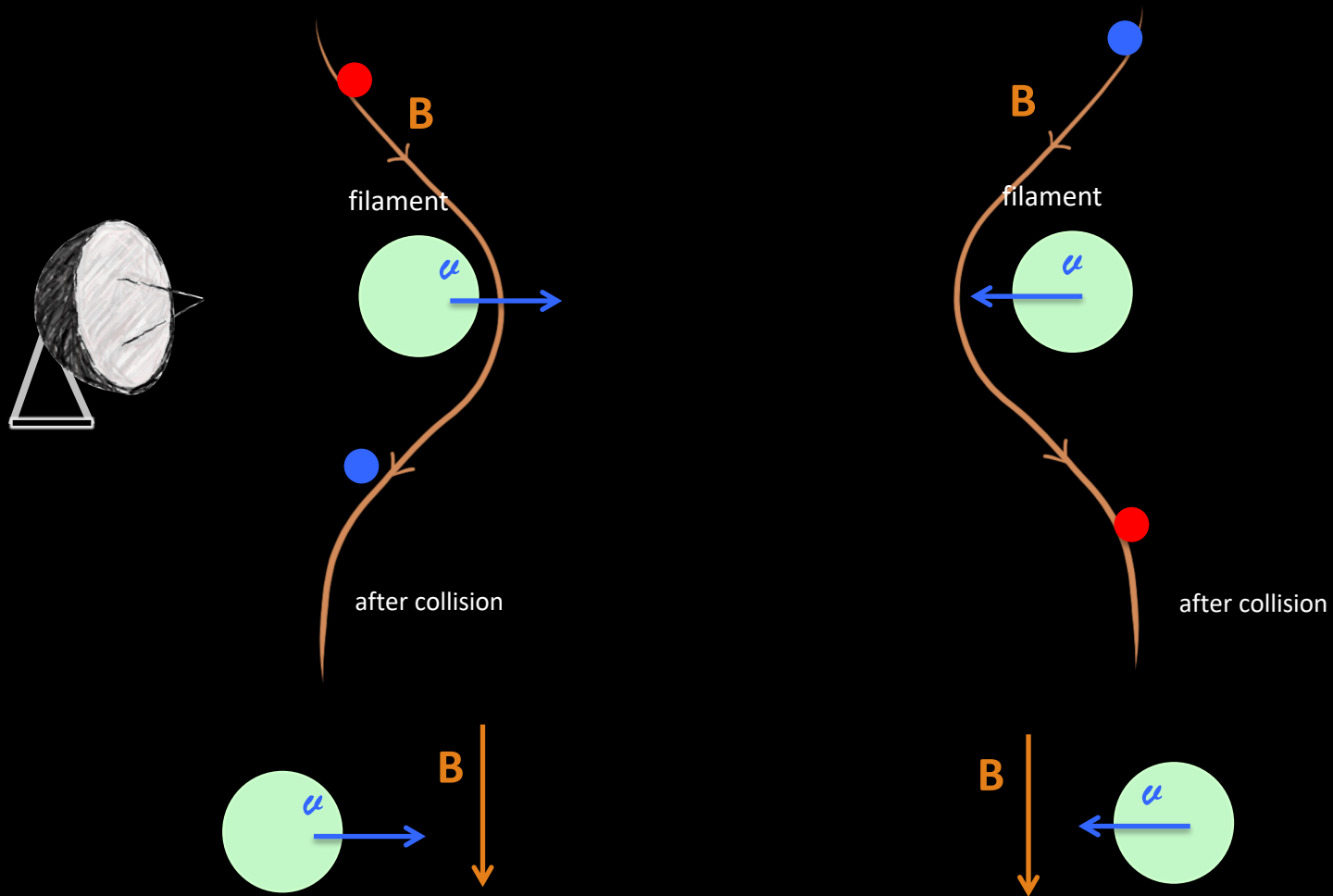
Bow-shaped Magnetic Field Morphology



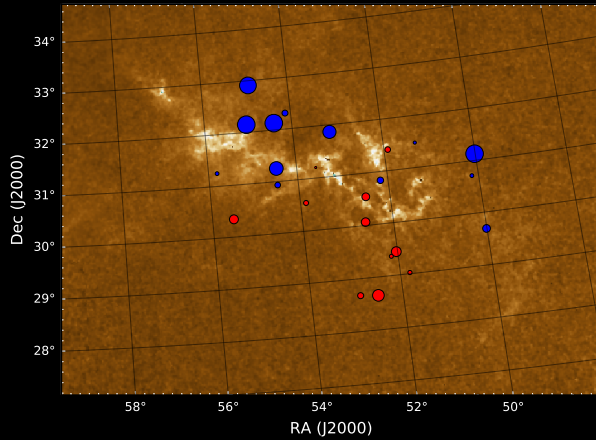
Inutsuka et al. 2015



Bow-shaped Magnetic Field Morphology



Perseus 3D Magnetic Field Morphology



longitude

3D GMF

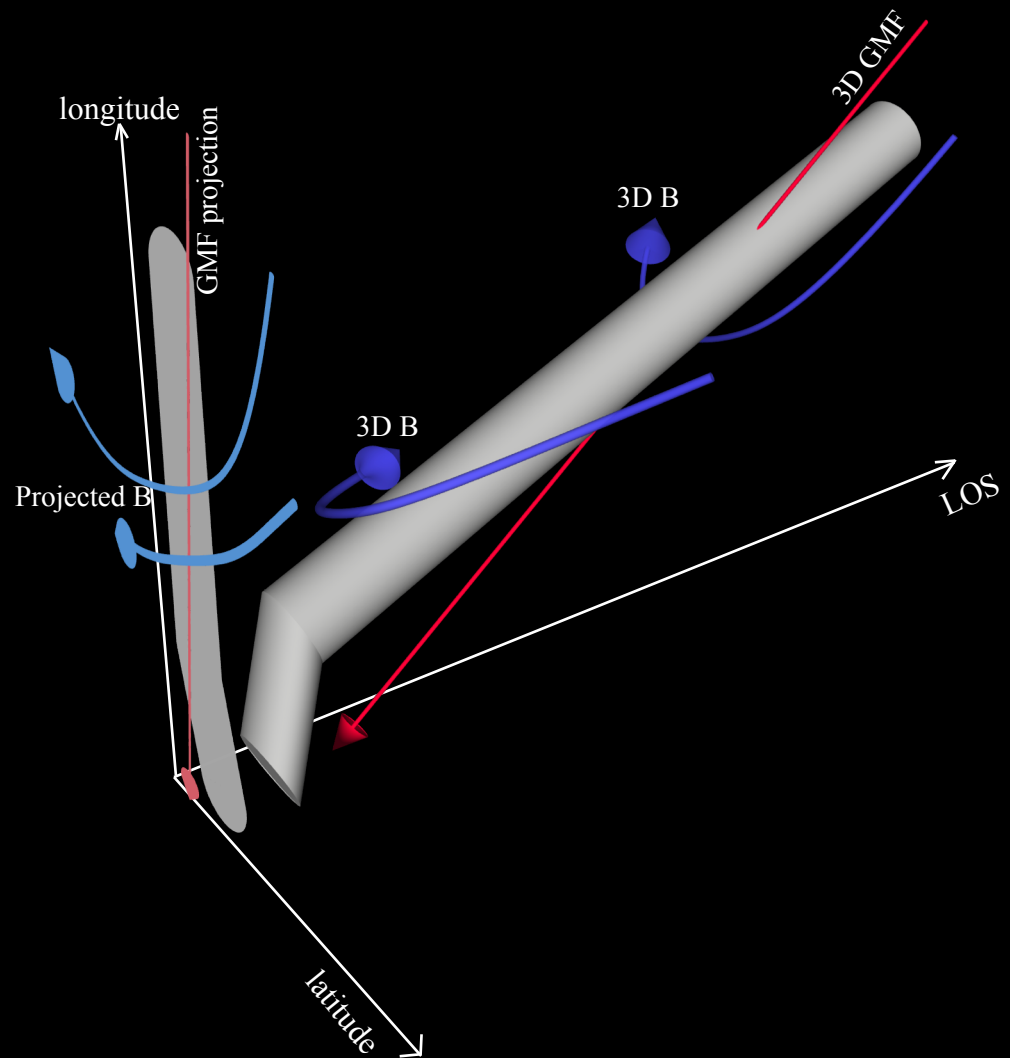
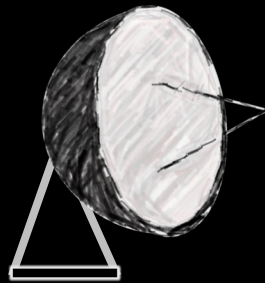
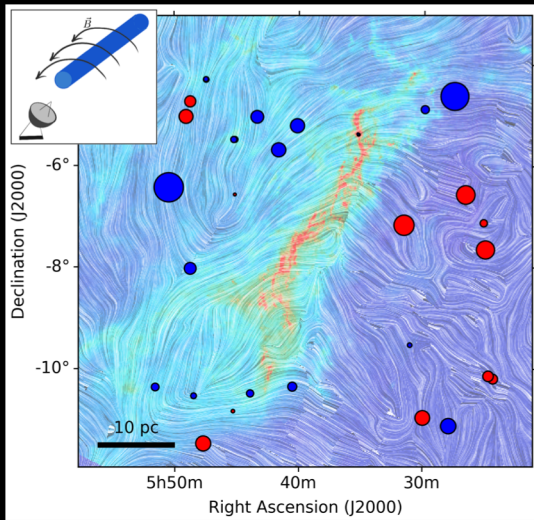
3D B

LOS

latitude

Tahani et al. Submitted

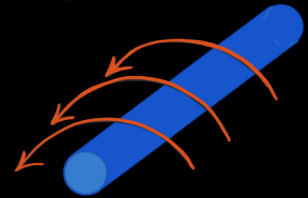
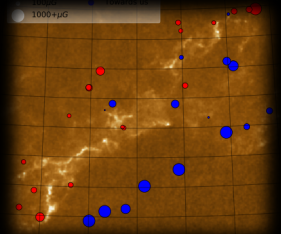
Orion A 3D Magnetic Field Morphology



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.