Exploring the Galactic Center Magnetic Field at High Spatial Resolutions

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Under the Advisement of Dr. Cornelia C. Lang
2022 Our Galactic Ecosystem
GC exhibits extreme properties compared to Galactic Disk
→ Rich in materials for SF
→ SFR below predicted rates and episodic
→ Need time for clouds to overcome turbulence (Henshaw+ 2019; Longmore+ 2013, others)
1 degree = 140 pc

Sagittarius A
1 degree = 140 pc

Non-Thermal Filaments (NTFs)

Sagittarius A
Non-Thermal Filaments (NTFs)

The Radio Arc

Sagittarius A

1 degree = 140 pc
Rotation Measure and B-field Properties

NTF: G359.54+0.18

➢ Thread-like total intensity
➢ Magnetic field traces total intensity orientation

\[ RM = 0.81n_e B_{||}L \]
\[ \chi = RM \cdot \lambda^2 + \chi_0 \]
Distribution of the NTFs in the GC

- NTFs may be related to larger synchrotron structures
- Recent study suggests energetic outflow
- NTFs appear to trace perpendicular B-field
Magnetic field from Dust Polarization in the GC

- First CMZ far-IR (240 mm) dust emission polarization of GC (PILOT balloon)
- Reveals a magnetic field that is remarkably well-ordered
- Field has an average tilt angle of ~20 degrees with respect to Galactic plane and aligned along molecular cloud lengths

Mangilli et al (2019)
Magnetic Fields in Galactic Nuclei

Observations show vertical B-fields originate near nucleus and may help to transport energetic materials (hot plasma) out of galaxy. Magnetic stress in circumnuclear rings can drive gas inflow (Balbus & Hawley 1998); also for barred galaxies, gas inflow also affected by magnetic field (Beck et al. 2005).
Recent Radio Arc Results Using the VLA

Paré et al. (2019, 2021)
See also Heywood et al. (2022) and Yusef-Zadeh et al. (2022)
High Resolution View of SNTF1

Point source with jet

Compact source

Paré et al. (2022, in progress)
SNTF2 is Southern Extent of Radio Arc

- Multiple individual filaments making up the Radio Arc
- Significant brightness variation within the filaments
- Isolated “Quill” filament also observed
- Evidence of other total intensity structure “Radio Shell”
SNTF3 in Complex Region of the GC

- Multiple filamentary structures comprising SNTF3
- One bright and several faint filaments within SNTF3
- Isolated filament ("the Wishbone") at termination of filaments of SNTF3
- Multiple other structures seen local to the NTFs like "The Fireball" and multiple point sources

Paré et al. (2022, in progress)
Polarized Intensity Calibration Underway

- Finalizing the calibration
- Will produce polarized intensity, RM, and intrinsic magnetic field distributions for all three targets
- Will be able to assess whether B-field connects to dust polarization B-field

Law et al. (2011)
Ongoing HAWC+ Observations of the GC

A Two-Color Polarimetric Survey of the Galactic Center

Principal Investigator: David Chuss
Proposal ID: 09_0054
Category: STARFORMATION
Keywords: GALACTIC CENTER, MOLECULAR CLOUDS, STAR FORMATION

Abstract

We propose a Legacy program to utilize HAWC+ to map the central region of the Galaxy at both 214 um and 89 um. We will utilize the shared-risk scan mode polarimetry observing strategy. The 214 um map is proposed as a test case because the total integration time is modest. Upon successful completion of the 214 map, (and the approval of the Cycle 9 TAC), we will proceed with the 89 um survey in the second year of the program. The resulting data products will yield a transformative data set for understanding the magnetic fields in both the cool dust ring in the central 200 pc and the warmer dust component and its relationship to the hot features of the Galactic center. Such a data set would elicit the role of the magnetic field in Galactic center dynamics from the 200 pc scale down to scales below a parsec.
ALMA Cycle 9 Proposal to Observe Sgr B2

➢ Will mosaic entire Sgr B2 region at 1 mm at 0.4” resolution

➢ Corresponds to physical resolution of ~1000 AU

➢ Will compare to 10,000 AU scale B-field observed with HAWC+

Mangilli et al (2019)
Exciting Prospects for GC Magnetic Fields

- Ongoing and upcoming research efforts will help elucidate the connection between the non-thermal and the dust polarization magnetic fields in the GC.
- Will be able to study the role of magnetic fields in star formation in an extreme region like the GC at high resolution.
- Could provide insight into role of magnetic fields during the epoch of reionization.

Let me know if you’re interested in being involved with the Sgr B2 proposal: dylan-pare@uiowa.edu