

Transition from a Toroidal to a Poloidal Magnetic Field in the Galactic Center

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The detailed nature and origin of the very strong magnetic field (MF) in the central few-hundred pc of the Galaxy has been a subject of controversy for nearly a quarter of century, and is important in understanding many phenomena in this region. Previous observations have been mainly based on sub-millimeter polarimetric observations of dense molecular clouds, or radio observations of non-thermal radio filaments. The former show that the MFs in dense molecular clouds runs almost parallel to the Galactic plane, indicating a *toroidal* MF[1]. By contrast, the radio filaments are aligned nearly perpendicular to the Galactic plane, and are highly polarized along the filaments' long axes, suggesting a large-scale, pervasive *poloidal* MF in the intercloud medium[2].

We report observations of the Galactic center (GC) region with a wide-field near-infrared polarimeter SIRPOL on IRSF. Near-infrared polarimetry enables us to probe the direction of the MFs not only in the dense molecular clouds, but in the intercloud regions toward the GC. Fig. 1 shows the MF direction (*E*-vectors of polarization in the K_S band) in the GC. The MF direction has strong dependence on the Galactic latitude. The histogram of the MF direction at $|b| \leq 0^\circ.4$ has a clear peak of $\sim 90^\circ$ (the direction parallel to the plane), suggesting a toroidal MF configuration in this region. At higher Galactic latitude ($|b| > 0^\circ.4$), the mean MF direction appears to swing to the direction nearly perpendicular to the Galactic plane. These results suggest a transition of the large-scale MF configuration from toroidal to poloidal in the GC region, at $|b| \sim 0^\circ.4$ [3,4].

Previously, the MF configuration of the GC has been viewed as poloidal in the diffuse, interstellar (intercloud) medium, and approximately parallel to the Galactic plane only in the dense molecular clouds. The new data presented here shows a toroidal MF prevails at $|b| < 0^\circ.4$, even outside dense molecular clouds, which radio and sub-mm surveys show are mostly confined to within $\sim 0^\circ.2$ of the Galactic plane. Toward higher Galactic latitudes ($|b| > 0^\circ.4$), the field changes from toroidal to poloidal configuration.

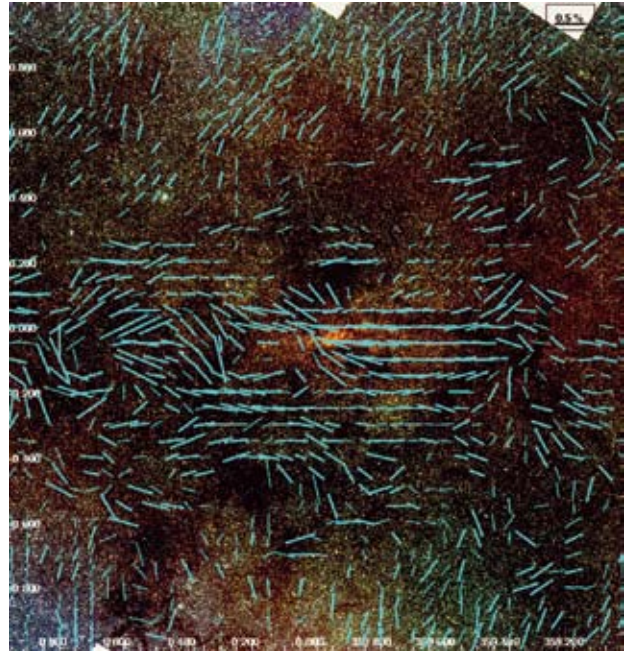


Figure 1: NIR mosaic image of the Galactic center (GC) region covering $2^\circ.0 \times 2^\circ.0$ in the Galactic coordinate, taken with the IRSF telescope and NIR camera SIRPOL. The three NIR bands are J (blue, $1.25 \mu\text{m}$), H (green, $1.63 \mu\text{m}$), and K_S (red, $2.14 \mu\text{m}$). The central-parsec star cluster of the GC is the bright yellow blob in the center of the image. Observed *E*-vectors of polarization are also plotted with cyan bars whose length indicates the degree of polarization. The vectors are averaged in a circle of $2'.4$ radius with a $3'.0$ grid, and plotted with thick bars (detected with more than 3σ) and thin bars (detected with $2-3\sigma$).

References

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- [3] Nishiyama, S., et al.: 2009, *ApJ*, **690**, 1648.
- [4] Nishiyama, S., et al.: 2010, *ApJ*, **722**, L23.