Bilateral symmetry in Supernova Remnants and the Connection to the Galactic Magnetic Field

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Is there a connection between the Galactic Magnetic Field and Supernova Remnants?

Gaensler (1998): a highly significant tendency for the axes of these SNRs to be aligned with the Galactic plane

Leckband et al. (1989): no preferred orientation between the angle of symmetry and the Galactic plane
Magnetic field lines (black) and cosmic ray electron distribution (green)

Quasi-perpendicular

Quasi-parallel

Isotropic

Model Radio Synchrotron Intensity
Method: Use a model of the Galactic magnetic field to model the appearance of SNRs at their specific location in the Galaxy
What do we know about the magnetic field of the Milky Way Galaxy?

How do we know its shape?
Rotation measure studies of extra-galactic point sources

Credit: VanEck/Brown
We compare Jansson & Farrar, 2012 to the model of Sun et al. 2008, which does not include a vertical halo component.
Modelling SNRs in the Galaxy
300+ SNRs known in the Galaxy
Single sided/asymmetric SNRs may result from density/B-field gradients (Orlando et al. 2007)
Model Synchrotron Intensity

$K(\alpha) B^{\alpha+1} \nu^{-\alpha} = j_\nu$

$\alpha = \text{spectral index}$
$\nu = \text{observation frequency}$
$j_\nu = \text{synchrotron intensity}$

(CRE distribution)
<table>
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<tr>
<th>G003.7-00.2</th>
<th>Model with vertical, X-shaped magnetic field (Jansson &amp; Farrar 2012)</th>
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<tr>
<td>0.5 kpc</td>
<td>1                      2               3              4               5              6             7               8               9             10</td>
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Model with no vertical magnetic field (Sun et al. 2008)

Quasi-perpendicular

Quasi-parallel
Galactic magnetic field model with an **X-shaped halo component**

Galactic Field model with **no vertical component** (toroidal halo component only)
Quasi-perpendicular models compared to data

Quasi-parallel models compared to data – JF12

Quasi-parallel models compared to data – Sun08

Difference in Bilateral Axis Angles (Model–Data) [°]
Quasi-perpendicular

Quasi-parallel

Milne 1987

Reich et al. 1992
Conclusions

• supportive of a connection between Galactic ISM and SNR morphology

• favours the quasi-perpendicular CRE scenario for this select sample of evolved bilateral SNRs

• future studies:
  • SNR case studies: magnetic fields of SNRs through polarization and rotation measures, progenitor studies, SNR distances (e.g., GALFACTS data)
  • Galactic magnetic field parameters such as turbulence, pitch angle, and shape of the vertical field
Supernova remnant Models & Images at Radio Frequencies (SMIRF)
http://www.physics.umanitoba.ca/snr/smirf/